FIVE ESTUARIES
OFFSHORE WIND FARM

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ENVIRONMENTAL STATEMENT

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Digital video aerial surveys of seabirds and marine mammals at Five Estuaries: Two-year report March 2019 to February 2021

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Executive Summary

In February 2019, Innogy now RWE acting as Five Estuaries Offshore Wind Farm Limited, commissioned HiDef Aerial Surveying Limited ('HiDef') to undertake a programme of high-resolution digital video aerial surveys of marine megafauna, ornithological and human activity to characterise the baseline environment for a proposed extension to the Galloper wind farm (now named the Five Estuaries Offshore Wind Farm).

The Five Estuaries ('VE') wind farm is located approximately 35km east of the Suffolk coast in the southern North Sea.

Monthly surveys were flown from March 2019 to February 2021. This equated to 24 surveys in total, comprising a complete two-year programme. HiDef designed a survey that placed transects at 2.5km separation across the 606km^2 survey area, including a 4km buffer around the proposed extension site ('the survey area').

Surveys were undertaken using an aircraft equipped with four (4) HiDef Gen II cameras with sensors set to a resolution of 2cm Ground Sample Distance ('GSD'). Each camera sampled a strip of 125m width, separated from the next camera by ~25m, which provides a combined sampled width of 500m within a 575m overall strip. To ensure that sufficient footage is available to allow either a design-based or model-based analysis, footage from two (2) or, in some months, three (3) cameras was analysed. The remaining footage has been archived.

Data analysis followed a two-stage process in which video footage is reviewed (with a 20% random sample used for audit) then the detected objects are identified to species or species group level (again with 20% selected at random for audit). The audit of both stages requires 90% agreement to be achieved.

Density and abundance estimates were calculated using strip transect analysis and a statistical technique called kernel density estimation ('KDE') was used to create density surface maps. In addition, known diving rates of certain species were used to estimate the proportion of diving animals that would be underwater at the time of survey.

Surveys were successful in characterising the bird and mammal species present across the VE survey area, recording a total 8,356 birds of 23 species and 583 marine mammals of two species over 24 surveys undertaken between March 2019 and February 2021. Additionally, 768 birds were partially identified to 16 separate species groups and 39 non-avian animals were partially identified to three species groups. The identification rate achieved to species level was 91.23% across the survey programme.

The primary observations from the surveys were:

- Fulmar *Fulmarus glacialis* observations peaked in the breeding season, with considerably more birds observed in Year 1 than Year 2;
- Gannets *Morus bassanus* were present across both breeding seasons with approximately three times as many birds recorded in Year 1 compared to Year 2. High numbers of autumn records suggest the area is used by migratory birds;
- Kittiwakes *Rissa tridactyla* were one of the most abundant species, generally peaking in winter months. The highest density occurred in March 2019;
- Lesser black-backed gulls *Larus fuscus* were most abundant in the survey area during the summer breeding season;

- Great black-backed gulls *Larus marinus* were recorded intermittently, peaking in late autumn and winter in both years;
- The most abundant species recorded throughout the survey period was guillemot *Uria aalge* with the highest density estimates present in winter, peaking in February 2020;
- Razorbill *Alca torda* was the second most abundant species of the survey programme, with peak densities occurring in winter;
- Harbour porpoise *Phocoena phocoena* were the most abundant marine mammal recorded at the survey site.

Maps produced for all species show widespread distribution throughout VE site and 4km buffer, making it difficult to determine areas of biological importance within the region. However, activity tended to be concentrated in the east of the VE region for many species.

The work undertaken by HiDef has collected 24 months' continuous data towards satisfying the survey requirements for a consent application.

1 Introduction

1 Galloper Wind Farm ('GWF'), run by RWE Renewables, is an operational offshore wind farm with 56 wind turbines, located adjacent to the operational Greater Gabbard Offshore Wind Farm ('GGOW') in the Outer Thames Estuary, approximately 27km from the Suffolk Coast.

2 In February 2019, Five Estuaries Offshore Wind Farm Limited commissioned HiDef Aerial Surveying Limited ('HiDef') to undertake a programme of high-resolution digital video aerial surveys of marine megafauna, ornithological and human activity to characterise the baseline environment for a proposed eastward extension to the Galloper wind farm (the 'Five Estuaries Offshore Wind Farm').

3 HiDef designed the survey methodology to provide information suitable to make an accurate assessment of abundance and distribution of seabirds and marine mammals in order to enable an environmental impact assessment of the Five Estuaries (VE) project. Surveys were conducted across both the proposed VE array and a surrounding 4km buffer (hereafter 'the survey area').

4 In certain months surveys overlapped with post construction monitoring work at the operational GWF.

5 A number of important bird sites which have been classified as Special Protection Areas ('SPA') under the European Council ('EC') Directive 2009/147/EC on the Conservation of Wild Birds ('the Birds Directive') are in the vicinity of the survey area. The Outer Thames SPA lies approximately 17km west of the development site and is designated for non-breeding red-throated diver *Gavia stellata* and is also in close proximity to the Galloper offshore wind farm. The site is also listed for breeding common tern *Sterna hirundo* and little tern *Sternula albifrons* in summer.

6 Alde-Ore Estuary SPA approximately 40km to the north west of the development site is important for avocet *Recurvirostra avosetta*, redshank *Tringa totanus*, ruff *Calidris pugnax* and Sandwich tern *Sterna sandvicensis*. It is important both as a feeding and breeding area. The saltmarsh within the SPA is also important for nesting lesser black-backed gulls *Larus fuscus*. The latter has been identified by nature conservation bodies as the main concern in relation to the operational Galloper Wind Farm and post construction monitoring focussed on this species is being undertaken.

7 Other migratory and transient bird species are also known to occur in the survey area, requiring year-round surveys to be carried out in order to characterise their abundance.

8 The project area is also visited by marine mammals, with harbour porpoise *Phocoena phocoena* the most numerous. The survey area is located within the winter area of the Southern North Sea Special Area of Conservation ('SAC'), which is designated under the European Commission Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Flora and Fauna ('the Habitats Directive') to protect this Annex II species.

9 This report ('the final report') provides the results from the 24 surveys undertaken between March 2019 and February 2021. Analysis is presented in the form of raw results, density surface distribution maps, abundance estimates with confidence estimates and summarised data on behaviour, age and flight direction. A discussion is provided as to the representativeness of the results. Flight height analysis for the full survey period will be included in a separate stand-alone report.

2 Methods

2.1 Survey flights

10 A series of strip transects were flown monthly between March 2019 and February 2021, following the methodology agreed between Five Estuaries Offshore Wind Farm Limited and HiDef in February 2019 (document reference: HP00100-001).

11 HiDef designed a survey that placed transects at 2.5km apart across the survey area, including a 4km buffer around the proposed VE array site, resulting in an overall survey area of 606km^2.

12 The survey design consisted of 17 strip transects extending roughly north-west to south-east, perpendicular to the depth contours along the coast. The transect-based non-stratified survey design helps to ensure that each transect samples a similar range of habitats (primarily relating to water depth), to reduce variation in bird and marine mammal abundance estimates between transects.

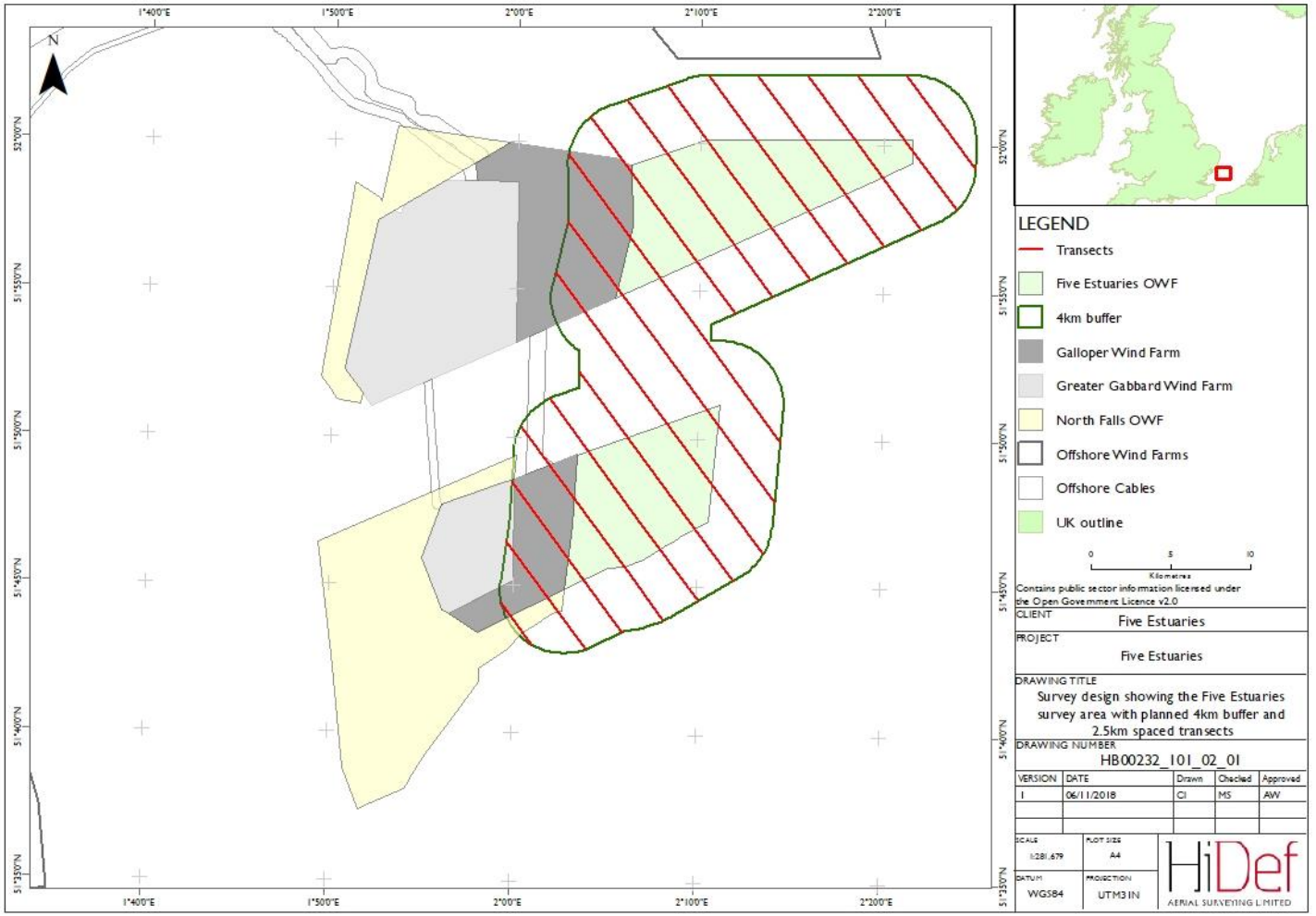
13 Surveys were undertaken using an aircraft equipped with four (4) HiDef Gen II cameras with sensors set to a resolution of 2 cm Ground Sample Distance ('GSD'). Each camera sampled a strip of 125m width, separated from the next camera by ~25m, providing a combined sampled width of 500m within a 575m overall strip.

14 A minimum target of 10% site coverage was set, with the following survey effort agreed between HiDef and VE. Across three (3) winter months (October, November and January) 10% site coverage was achieved over the site, with data from two (2) cameras processed. Due to concurrent surveys across the operational Galloper array for post-construction monitoring, a supernumerary 15% site coverage was achieved for all other months (March to September, December and February), with data from three (3) cameras processed for these nine (9) surveys each year. This was conducted for both year one and year two of surveying. This ensured a survey with sufficient coverage and number of transects, with the remaining unprocessed data archived.

15 The surveys were flown along the transect pattern shown in Figure 1 at a height of approximately 550m above sea level ('ASL') (~1800'). Flying at this height ensures that there is no risk of flushing those species which have been proven to be easily disturbed by aircraft noise. Thaxter *et al.* (2016), recommends a minimum flight altitude of 500m ASL.

16 Position data for the aircraft was captured from a Garmin GPSMap 296 receiver with differential GPS enabled to give 1m accuracy for the positions and recording updates in location at one second intervals for later matching to bird and marine mammal observations.

Figure 1 Survey design showing the VE survey area with planned 4km buffer and 2.5km spaced transects



2.2 Data Review and Object Detection

17 Data were viewed by trained reviewers who marked any objects in the footage as requiring further analysis, as well as determining which are birds, marine megafauna (defined within this report as cetaceans, pinnipeds or other large, non-avian marine fauna) or anthropogenic objects such as ships or buoys.

18 As part of HiDef's quality assurance ('QA') process, an additional 'blind' review of 20% of the raw data was carried out and the results compared with those of the original review. If 90% agreement is not attained during the QA process, then corrective action is initiated: the remaining data set is reviewed and where appropriate, the failed reviewer's data discarded and all the data re-reviewed. In addition, additional training is then given to the reviewer to improve performance. No re-reviews were required for the data set.

19 An object is only recorded where it reaches a reference line (known as 'the red line') which defines the true transect width of 125m for each camera. By excluding objects that do not cross the red line, biases to abundance estimates caused by flux (movement of objects in the video footage relative to the aircraft, such as 'wing wobble') are eliminated.

2.3 Object Identification

20 Images marked as requiring further analysis were reviewed by specialist ornithologists[1] and marine mammal specialists[2] for identification to the lowest taxonomic level possible and for assessment of the approximate age and the sex of each animal, as well as any behaviour traits visible from the imagery.

21 At least 20% of all objects were selected at random and subjected to a separate 'blind' QA process. If less than 90% agreement was attained for any individual camera then corrective action is initiated: if appropriate, the failed identifier's data were discarded and the data re-identified. Any disputed identifications were passed to a third-party expert ornithologist for a final decision[1]. The level of agreement within the QA process is calculated as the final number of agreements as a percentage of all identifications subjected for QA for the entire survey.

22 All objects were assigned to a species group and where possible, each of these then further identified to species level. The species identifications were given a confidence rating of 'possible', 'probable' or 'definite'[3].

23 It is important to note that these confidence ratings are not a standardised assessment and thus an estimate of probability cannot be applied to identification reliability. The likelihood of achieving a definite or probable identification is not consistent for all component members of a species group. For example, someone undertaking identification of a large auk species may find it easier to be confident of a guillemot identification than a razorbill. Confidence scores should not be used to filter or weight the probability

[1] HiDef currently employs three (3) of the ten (10) current members of the British Birds Rarities Committee ('BBRC') as expert ornithologists

[2] HiDef staff have long-standing experience in marine mammal identification, regularly undertaking boat surveys as part of ESAS (European Seabirds At Sea Partnership). They process thousands of cetacean images, hold regular internal training sessions and have access to marine specialists within our wider company BioConsult SH.

[3] Definite: as certain as reasonably possible. Probable: very likely to be this species or species group. Possible: more likely to be this species or species group than anything else.

of 'large auk' being one species or another in any analysis, as this will lead to biased results, particularly if the identification rate is low.

24 Any animals that could not be identified to species level were assigned to a category 'No ID'. If, on occasion, the unidentified bird is suspected of belonging to two different possible genera, then a broader group category may be used. For example, a bird would usually be assigned to the group category 'Shearwater species' if identified as a Manx shearwater *Puffinus puffinus*, or to 'Auk species' if identified as a guillemot. However, if the bird has the potential to be either, then it would be assigned to the group category 'Shearwater / Auk species' and the species level recorded as 'No ID'.

25 In the case of birds, additional information was recorded on basic behaviour (whether the bird was sitting, loafing on land or other objects or flying). More detail was recorded where possible on foraging behaviour, approximate age, sex and any other details of interest. Aging of birds was based on moults and is mostly conducted on flying individuals and species which show seasonal variation in plumage.

26 Marine mammals and other marine megafauna were recorded using the same process. Animals were first assigned to a species group (e.g. 'cetacean species') and then given a species level identification (e.g. 'harbour porpoise', 'minke whale' or 'No ID'). If a precise species group could not be ascertained, then the record was assigned to a broader group category (e.g. 'seal or small cetacean species') and the species level recorded as 'No ID'. In the case of marine mammals, surfacing behaviour was also recorded as either 'surfacing', 'surfacing at red line', 'submerged' or 'unknown'. Surfacing behaviour was defined as any part of the non-avian animal's body breaking the surface of the water in any frame. However, for the purposes of calculating availability bias, harbour porpoise surfacing behaviour was also classified if the animal's dorsal fin was above the water in the frame nearest to the 'red line' on the operator's screen ('surfacing at red line'). Sexing and aging of marine mammals was carried out where possible.

27 Anthropogenic activity was recorded as either 'man-made object', 'fishing boat' or 'other boat'. Further details were noted in the comments, including further specifying the type of object (e.g. 'fishing buoy', 'marker buoy', 'wind turbine') or noting any names and numbers that can be seen.

2.4 Data quality check

28 HiDef's method is designed to ensure low rejection of data on grounds of quality, such as low cloud, sun glare or other issues. Care is taken to avoid survey in low cloud or poor visibility by careful selection of survey days with the correct survey conditions. In the unlikely event that low cloud occurs during a survey, the pilot is instructed to either avoid areas affected and return to those at the end of the survey, return to a nearby base and wait for cloud to clear or abandon the survey. Sun glare is avoided by design of the survey rig which uses angled cameras on a rotating plinth. This means that the cameras are angled away from any sun glare at all times, with the camera rig rotated in between transects to ensure that this angle is maintained.

29 All data undergoes a full check on return to the office consisting of a review of every camera and every transect. Any issues that may affect usability of the data are flagged at this stage may result in a re-fly of the survey.

30 Glare is recorded on all cameras throughout the survey. For each individual survey, on one of the cameras (known as the 'weather camera' the following weather conditions are also recorded – sea state and turbidity. Operators carrying out bird and mammal identification carry out environmental checks of the data and score sun glare and turbidity on a scale from 1 - 4 in which score 4 is a high degree of sun glare or turbidity in which the data should not be used because it would affect detection rates. Sea

state is scored based on the WMO Sea State code, in which score 6 or more is a high degree of sea state in which the data should not be used as it would affect detection rates.

31 Tables are provided below to show how glare, sea state and turbidity are scored.

Table 1 Scoring criteria for recording glare and turbidity

Score	Criteria
0	Can't tell / Not Recorded / Over land
1	None present
2	Slight
3	Moderate
4	Strong

Table 2 Scoring criteria for recording sea state as outlined by the WMO Sea State code

WMO Sea State Code	Wave height	Characteristics
0	0 metres	Calm (glassy)
1	0 to 0.1 metres	Calm (rippled)
2	0.1 to 0.5 metres	Smooth (wavelets)
3	0.5 to 1.25 metres	Slight (first whitecaps)
4	1.25 to 2.5 metres	Moderate (many whitecaps)
5	2.5 to 4 metres	Rough (some spray)
6	4 to 6 metres	Very rough (large waves, many whitecaps, much spray)
7	6 to 9 metres	High (streaks of wind-blown foam)
8	9 to 14 metres	Very high
9	Over 14 metres	Phenomenal

2.5 Final processing

32 All data were geo-referenced, taking into account the offset from the transect line of the cameras, and compiled into a single output; Geographical Information System ('GIS') files for the Observation and Track data are issued in ArcGIS shapefile format, using UTM31N projection, WGS84 datum.

2.6 Data analysis

2.6.1 Data treatment

33 All observations were compiled for analysis and presentation. Records identified to species level were separated out from records of partially identified individuals to group level only, and the following analyses undertaken on both datasets. No apportioning of 'partially identified' birds or mammals to species level was undertaken. All confidence levels of species identifications were used in the analysis. In the analysis of species groups, rationalisation of the full list of species groups was carried out to simplify the interpretation.

34 Using the observation data, the total number of records found during the strip transect surveys was calculated and seasonal abundance graphs created. Where available, behaviour and age data was compiled and presented in tables.

2.6.2 Population and density estimates

35 After raw totals were calculated, the same data were then used to estimate population (the total number of individuals estimated to exist within the survey area) and density estimates as follows.

36 In a strip transect analysis, each transect is treated as an independent analysis unit, and the assumption is made that transects can be treated as statistically independent random samples from the site. The length of each transect and its breadth (i.e. the width of the field of view of the camera) multiplied together give the transect area; dividing the number of observations on that transect by the transect area gives a point estimate of the density of that species for the site. The density of animals at the site (and hence the population size), the standard deviation, 95% confidence intervals ('CI') and coefficient of variation ('CV') are then estimated using a non-parametric bootstrap method with replacement (Buckland *et al.*, 2001).

37 The upper and lower 95% confidence intervals were calculated by way of a blocked bootstrapping technique to ensure equal transect effort was sampled across each iteration. This was done by using transect ID as the sampling unit with replacement, and then randomly sampling until the total length of the sampled transects equalled approximately the same length as the total survey length. A total of 5,000 bootstrap iterations were performed from which we calculated the mean and standard deviation of the sampled means, as well as the relative standard error as defined by the standard deviation divided by the mean. Data were processed in the R programming language (version 3.4.3) and code can be provided on request. For most species these abundance estimates relate to absolute abundance, but for diving species (auks and marine mammals) the abundance relates to relative abundance. In Section 2.6.4 we describe our method for taking account of availability, which provides a reasonable measure of absolute abundance.

38 The density estimate is expressed as the average number of animals per square km surveyed over the whole survey area, and the population estimate is then calculated as the density multiplied up to the area of the whole survey area (project area with 4 km buffer). The upper and lower CI define the range that the population estimate falls within with 95% certainty. The CV, also referred to as the relative standard error, is a measure of the precision of the population and density estimates.

2.6.3 Availability bias

39 In wildlife surveys, a proportion of seabirds or marine mammals that spend any time underwater, especially while feeding, will not be detectable at the surface. This may lead to an under-estimate of their abundance during surveys, which is known as 'availability bias'. For species that make long dives underwater, this bias may be significant (for example, shag).

40 There are two main approaches to attempt to account for availability bias: by using double platform surveys (for example Borchers *et al.* 2002) which is logistically difficult to achieve and relatively expensive; and by using known data on time spent underwater to apply correction factors to abundance estimates (for example Barlow *et al.*, 1988).

41 Barlow used an equation to determine the proportion of time that an animal is not available in equation 1:

$$\Pr(being\ visible) = \frac{(s+t)}{(s+d)}$$

Where *s* is the average time spent below the surface, *t* is the window of time that the animal is within view and *d* is the average time spent at the surface. In the case of digital video surveys, the value of *t* is negligibly small and is treated as 0.

42 Due to a lack of diving rate data for many species, availability bias corrections were only conducted on four species: guillemots, razorbills, puffins and harbour porpoises.

2.6.3.1 Seabirds

43 All available data for seabirds relate to diving behaviour obtained by direct observation, or in the case of guillemots and razorbills, to data obtained during the breeding season using data loggers. Thaxter *et al.* (2010) give average times for these species engaged in flying, feeding and spent underwater during the chick-rearing period. We have used the mean time spent underwater (1.9 and 0.8 hours for guillemots and razorbills respectively) as a percentage of the mean time spent at sea not flying (8.0 and 4.6 hours respectively). Thus, the percentage time spent underwater for guillemots is 23.75% and for razorbills of 17.4%. For puffins, data from data loggers were used from Spencer (2012), which estimated that puffins spend 14.16% of daylight time underwater.

44 These correction values can only be applied to estimates of relative abundance of birds sitting on the sea, which should then be added to the abundance of flying birds to give an estimate of absolute abundance for the species overall. For this reason, it was necessary to calculate the percentage of sitting birds as a total of all observations and apply these to the estimates of abundance for each of the three species. Because of low sample sizes of guillemots and razorbills in many months, we used the percentage of sitting birds to calculate the correction factors for abundance estimates within the proposed development area. For some species, too few observations were available to assess the ratio of sitting to flying birds with confidence and consequently, a ratio was used that pooled data for certain species. We have used these percentage figures to scale up the relative abundance estimate of guillemots, razorbills and puffins sitting on the sea by factors of 1.2375, 1.174 and 1.1416 respectively, and then added these corrected abundance estimates for sitting birds to the abundance estimate of flying birds. A scaling factor was also applied for large auks and auk species in proportion to the ratio of the estimated abundance of sitting guillemots, razorbills and puffins to each other and to other species within each of the mapped grid cells.

2.6.3.2 Marine mammals

45 Harbour porpoise abundance is also affected by availability bias, and further complicated because detections of animals are also possible while they are submerged. There are two approaches to using known diving rates to correct for availability bias for this species: to apply a correction factor to the density of animals that were recorded surfacing only using data on the surfacing rates from tagged animals; or to apply a correction factor to the density of all animals using the proportion of time spent at known depths by tagged animals.

46 The depth above which animals are available for detection is not known and is likely to vary according to the turbidity of the water, and perhaps other factors, but has been estimated to be 2m by Teilmann *et al.* (2013) when correcting for availability bias during visual aerial surveys of harbour porpoise.

47 Teilmann *et al.* (2013) provides detailed information which accommodates variation in time of year, geographical location and time of day in the proportion of time spent in the surface 2m of the water column and breaking the surface. All of these metrics relate to model outputs in Teilmann and are used to refine the predicted amount of time that harbour porpoise spend surfacing in the outputs. The tagging study of Teilmann did not extend to the area of the North Sea surrounding the VE site, and no other

data are available on surfacing behaviour for this species in the relative area. For our analysis, we assumed that diving behaviour in the VE region was similar to that in North Sea areas of similar depths in Teilmann's study and used the model outputs from the North Sea in our calculations. In order to estimate the density of surfacing harbour porpoise, it was necessary for us to use the density of all detectable animals and calculate the proportion where the dorsal fin was snapshot surfacing. This was done using data from all months combined because sample sizes were too small to be accurate when calculating the surfacing proportions in individual months. We multiplied the calculated density of harbour porpoise by the proportion of snapshot surfacing encounters in our surveys and divided this by the proportion of surfacing behaviour from Teilmann *et al.* (2013) in Table 3, to derive the estimates of absolute density and abundance used in Table 90.

Table 3 Correction factors used to account for availability bias for harbour porpoise at different times of the year and at different times of the day (after Teilmann *et al.* 2013)

Month	Behaviour			
	Surface		0 – 2 m	
	09:00 – 15:00	15:00 – 21:00	09:00 – 15:00	15:00 – 21:00
January	0.0490	0.0476	0.4381	0.418614
February	0.0398	0.0384	0.3748	0.355348
March	0.0543	0.0529	0.4637	0.444271
April	0.0646	0.0632	0.5708	0.551331
May	0.0563	0.0549	0.5262	0.506735
June	0.0518	0.0503	0.5093	0.489809
July	0.0493	0.0479	0.5116	0.492099
August	0.0530	0.0516	0.4508	0.431293
September	0.0420	0.0406	0.4468	0.427348
October	0.0413	0.0399	0.4422	0.42276
November	0.0406	0.0392	0.4439	0.424431
December	0.0429	0.0415	0.4790	0.459555

48 Availability bias was not corrected for in other marine mammal species due to the low number of individuals present, and a lack of information about diving patterns.

2.6.4 Density Mapping

49 Density maps were created to display the distribution of key species only. Key species were selected based on their high abundance or their significance at nearby SPAs. For diving species (guillemot and

razorbill), density mapping was undertaken using 'relative' density estimates, *prior* to adjustment for availability bias.

50 The density maps have been derived using a Watson-Nadaraya type kernel density estimation ('KDE') technique (Simonoff, 1996). In KDE, a small 'window' function (the kernel) is used to calculate a local density at each point in the study area. To evaluate the density at a given point, the kernel is centred on that point and all the observations within the window are summed to obtain a local count. The total area of the transect(s) intersecting the window is then summed to obtain a local measure of effort. By dividing the local count by the local effort, a local density estimate is obtained. To build a density map, the study area is covered with a fine mesh of study points and the density is calculated at each point in the mesh in turn.

51 Kernel techniques are robust and not as complex as other density estimation techniques because they have few parameters; as a result, they are arguably the easiest density surface technique to reproduce independently. The only variables are the size and shape of the kernel or window function. For these analyses, we have used a Gaussian window function, which has the advantages of being smooth, rotationally symmetric, and easy to compute. The shape of the Gaussian window is determined by a single width parameter; the selection of this parameter is the only variable in the computation of the density maps.

52 Rather than set the width parameter arbitrarily, we have used a leave-one-out cross validation method. Cross validation estimates the predictive power of a model by removing some of the data from the data set and using the remainder of the data and the model to predict the values for the data that was removed. The closer the predicted values represent the removed data, the better the model performance and the width parameter used in the model.

53 To apply cross validation to the survey area, each transect is subdivided into 1km long segments. To evaluate a particular choice of kernel width, each segment is removed in turn, use the kernel and the remaining data to predict the density of the missing segment and subtract the known value from the prediction to obtain an error score. This process is repeated for every segment and the error scores for all segments are squared and summed to give a total performance score for that particular choice of kernel width. The kernel width is then varied and the process repeated; if the new score is lower than the old, the new kernel width is a better choice than the previous value. An exhaustive search over all kernel widths is then used to identify the best global choice. The result is a smooth density estimate which has been derived without any manual parameter selection. The whole process is repeated from scratch for each map, as different kernel sizes are appropriate for different species.

54 It should be noted that several of the KDE maps are effectively flat (i.e., they appear the same colour throughout the study area). These correspond to distributions where the density surface as obtained from a small local kernel was not effective at predicting missing data; this can happen with evenly distributed birds, but mainly happens for very sparse distributions. In the case of sparse distributions, the 'flat' map does not necessarily mean that the true underlying distribution is 'flat'; it could mean that the data doesn't contain enough evidence to determine what the underlying distribution is. It is therefore useful to refer back to the population estimates for the corresponding map when looking at these 'flat' densities; we have also overlaid the relevant observations as dots to help with interpretation of the maps. In extreme cases, the kernel density maps were not included in the results section, and the data were only presented as dot maps. This occurred where there were fewer than five observations of the species in question.

55 For less abundant bird and non-avian species, as well as those partially identified to group level, density mapping was not undertaken. Instead, distribution is illustrated by dot maps.

3 Results

3.1 Survey effort

56 The date, number of transects and survey effort (as expressed by length of transects) undertaken between March 2019 and February 2021 are shown in Table 4. The number of transects and the total length of transects are those used in subsequent analysis (see Figure 1 for the aircraft flight pattern).

57 The flight variations and environmental conditions of glare, sea state and turbidity have been included in Table 5. On this basis, 100% of all data collected could be used in the subsequent analysis. Tracks for each flight are shown in Figure 2 and Figure 3.

Table 4 Survey effort across the VE survey area between March 2019 and February 2020

Survey date	Survey Number	Number of transects analysed	Total length of transects analysed (km)	Area covered (km²)	% covered
26 March 2019	1	17	240.20	90.07	14.87
5 April 2019	2	17	245.75	92.16	15.22
11 May 2019	3	17	243.91	91.47	15.10
6 June 2019	4	17	240.12	90.04	14.87
1 July 2019	5	17	240.90	90.34	14.92
28 August 2019	6	17	240.14	90.05	14.87
10 September 2019	7	17	240.42	90.16	14.89
5 October 2019	8	17	240.43	60.71	10.02
6 November 2019	9	17	242.01	66.31	10.94
23 December 2019	10	17	239.48	89.80	14.83
18 January 2020	11	17	265.16	66.29	10.94
14 February 2020	12	17	241.35	90.50	14.94
11 March 2020	13	17	240.59	90.22	14.90
09 April 2020	14	17	240.68	90.25	14.90
03 May 2020	15	17	234.27	87.85	14.50
20 June 2020	16	17	240.27	90.10	14.88
21 July 2020	17	17	240.04	90.01	14.86
05 August 2020	18	17	239.93	89.97	14.85
02 September 2020	19	17	240.73	90.27	14.90

Survey date	Survey Number	Number of transects analysed	Total length of transects analysed (km)	Area covered (km²)	% covered
09 October 2020	20	17	240.12	64.31	10.61
05 November 2020	21	17	240.20	64.38	10.62
15 December 2020	22	17	240.38	90.14	14.88
22 January 2021	23	17	240.26	62.86	10.37
13 February 2021	24	17	240.50	90.19	14.89

Table 5 **Survey summary outlining times and plane flight height over the survey area and environmental conditions between March 2019 and February 2021**

Survey date	Survey Number	Start of survey	End of survey	Hours on task (hrs)	Camera resolution	Glare (average)	Sea state (average)	Turbidity (average)
26 March 2019	1	09:15	13:00	03:45	2cm	1.00	3.00	0.00
5 April 2019	2	10:45	14:55	04:10	2cm	1.07	3.02	0.00
11 May 2019	3	10:20	14:15	03:55	2cm	1.38	3.03	0.00
6 June 2019	4	09:20	13:10	03:50	2cm	1.21	3.83	1.32
1 July 2019	5	09:20	13:05	03:45	2cm	1.00	2.98	1.03
28 August 2019	6	09:00/14:45	13:30/15:15	04:00	2cm	1.00	1.05	1.00
10 September 2019	7	09:00	12:40	03:40	2cm	1.01	2.00	1.01
5 October 2019	8	11:10	15:05	03:55	2cm	1.01	2.12	0.99
6 November 2019	9	10:35	14:50	04:15	2cm	1.00	1.99	0.00
23 December 2019	10	10:35	13:10	02:35	2cm	1.14	4.99	0.00
18 January 2020	11	09:30	13:30	04:00	2cm	1.02	3.97	0.01
14 February 2020	12	09:55	13:40	03:45	2cm	1.05	3.00	0.04
11 March 2020	13	09:48	13:32	3:44	2cm	1.00	3.85	1.00
09 April 2020	14	13:03	16:48	3:45	2cm	1.10	2.87	0.01

Survey date	Survey Number	Start of survey	End of survey	Hours on task (hrs)	Camera resolution	Glare (average)	Sea state (average)	Turbidity (average)
03 May 2020	15	09:05	12:51	3:46	2cm	1.00	1.88	0.01
20 June 2020	16	07:13	10:55	3:42	2cm	1.04	2.79	1.00
21 July 2020	17	07:08	10:53	03:45	2cm	1.13	2.38	0.00
05 August 2020	18	07:06	10:42	03:36	2cm	1.02	3.02	0.10
02 September 2020	19	08:05	11:59	03:54	2cm	1.00	1.00	1.00
09 October 2020	20	07:58	11:31	03:33	2cm	0.75	2.96	0.00
05 November 2020	21	12:03	15:26	03:23	2cm	1.03	2.98	0.01
15 December 2020	22	10:31	13:46	3:15	2cm	1.34	2.34	1.00
22 January 2021	23	10:30	13:36	3:06	2cm	1.25	3.00	0.02
13 February 2021	24	10:02	13:48	03:46	2cm	1.16	5.91	0.00

Figure 2 Flight pattern for each monthly survey over the VE survey array area between March 2019 and February 2020

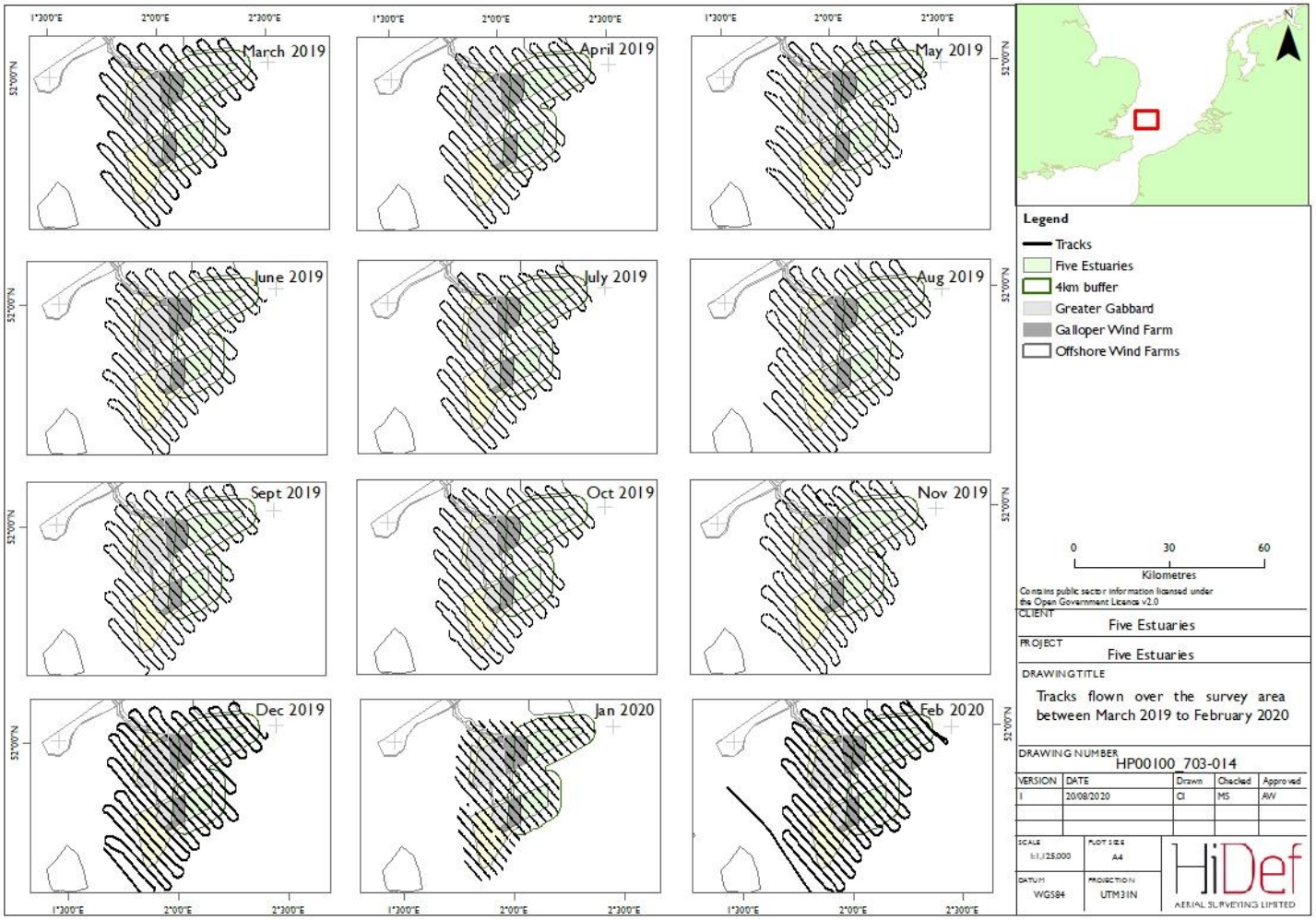
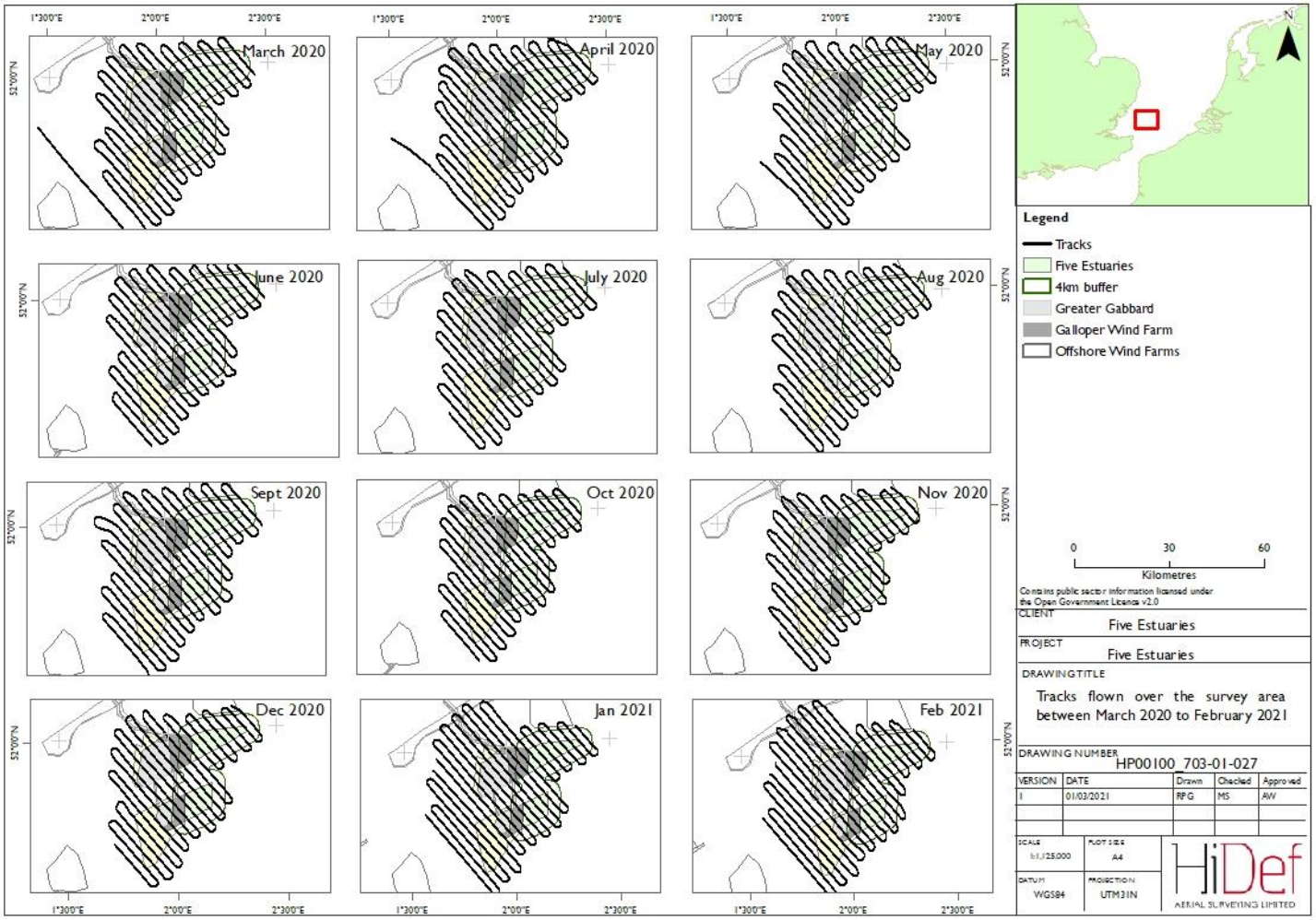


Figure 3 **Flight pattern for each monthly survey over the VE survey array area between March 2020 and February 2021**



3.2 Survey results

58 The total number of objects detected in each survey, as well as uncorrected numbers of species and species group are presented in Table 7 to Table 10. Some observations fall outside the study area and thus are not included in analysis presented in Section 3.3 onwards.

59 Each animal was assigned to at least a species group (e.g. large auk), and where possible these were also assigned a further species level identification (e.g. guillemot or razorbill) with confidence levels of 'Possible', 'Probable' or 'Definite'. Any animals that could not be identified to species level were assigned to a category 'No ID' in the species column. The analysis of data to species level uses all levels of identification confidence. The overall identification rate of birds and non-avian animals to a species level (not including 'No ID's) for the 24 surveys are given in Table 6.

Table 6 Survey identification rates at the VE survey area between March 2019 and February 2021 inclusive

Survey date	ID rate (%)
26 March 2019	95.89
5 April 2019	95.15
11 May 2019	89.46
6 June 2019	94.59
1 July 2019	98.45
28 August 2019	88.74
10 September 2019	77.29
5 October 2019	90.58
6 November 2019	94.39
23 December 2019	92.21
18 January 2020	90.80
14 February 2020	88.66
11 March 2020	94.20
09 April 2020	87.86
03 May 2020	89.11
20 June 2020	91.29
21 July 2020	96.40
05 August 2020	94.52
02 September 2020	92.02

Survey date	ID rate (%)
09 October 2020	86.83
05 November 2020	89.18
15 December 2020	88.47
22 January 2021	93.82
13 February 2021	90.49
Average	**91.23**

Table 7 **Number of objects detected during each survey assigned to species level March 2019 and February 2020. Survey number dates can be observed in Table 4. Species highlighted in light grey are considered to be in low or relatively low abundances.**

Species	Scientific Name	Month												Year 1 Total
		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	
Red-throated diver	*Gavia stellata*	2	0	0	0	0	0	1	0	0	1	0	5	9
Fulmar	*Fulmarus glacialis*	26	5	16	17	7	39	37	2	2	0	3	1	155
Gannet	*Morus bassanus*	75	27	3	53	13	100	20	32	137	2	0	50	512
Cormorant	*Phalacrocorax carbo*	0	0	0	0	0	0	6	0	0	0	0	0	6
Great crested grebe	*Podiceps cristatus*	0	0	0	0	0	0	0	0	0	0	1	0	1
Arctic skua	*Stercorarius parasiticus*	0	0	0	0	0	0	1	0	0	0	0	0	1
Great skua	*Stercorarius skua*	0	0	0	0	0	4	2	0	0	0	0	0	6
Kittiwake	*Rissa tridactyla*	366	109	52	37	9	14	33	7	58	83	29	84	881
Little gull	*Hydrocoloeus minutus*	0	2	0	0	0	0	0	4	4	0	0	0	10
Black-headed gull	*Chroicocephalus ridibundus*	5	0	0	0	0	0	1	2	2	0	0	0	10
Common gull	*Larus canus*	0	1	0	1	0	0	0	0	0	1	1	5	9
Lesser black-backed gull	*Larus fuscus*	1	30	4	239	152	92	21	1	3	4	0	1	548
Herring gull	*Larus argentatus*	0	0	0	13	12	6	0	1	2	1	2	0	37
Great black-backed gull	*Larus marinus*	3	6	0	2	0	4	32	9	6	4	4	1	71
Sandwich tern	*Thallaseus sandvicensis*	0	1	0	0	0	0	0	1	0	0	0	0	2

Species	Scientific Name	Month												Year 1 Total
		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	
Common tern	*Sterna hirundo*	0	0	0	0	0	0	1	0	0	0	0	0	1
Guillemot	*Uria aalge*	545	305	11	0	11	12	4	27	109	168	157	1368	2717
Razorbill	*Alca torda*	333	46	8	0	1	2	0	50	41	290	49	230	1050
Puffin	*Fratercula arctica*	1	0	0	0	0	0	0	0	0	0	0	0	1
Grey seal	*Halichoerus grypus*	1	0	0	0	0	2	0	0	0	0	0	1	4
Harbour porpoise	*Phocoena phocoena*	23	6	3	13	10	46	43	10	77	12	4	15	262
Total		**451**	**1381**	**538**	**97**	**375**	**215**	**321**	**202**	**146**	**441**	**566**	**1761**	**6293**

Table 8 **Number of objects detected during each survey assigned to species level March 2020 and February 2021. Survey number dates can be observed in Table 4. Species highlighted in light grey are considered to be in low or relatively low abundances.**

Species	Scientific Name	Month												Year 2 Total	Grand Total
		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb		
Wigeon	*Mareca penelope*	0	0	0	0	0	0	8	0	0	0	0	0	8	8
Red-throated diver	*Gavia stellata*	1	2	2	0	0	0	0	1	0	3	5	4	18	27
Fulmar	*Fulmarus glacialis*	2	0	9	3	14	4	4	0	1	0	0	1	38	193
Gannet	*Morus bassanus*	0	2	1	4	9	6	40	26	61	10	2	8	169	681
Cormorant	*Phalacrocorax carbo*	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Great crested grebe	*Podiceps cristatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Golden plover	*Pluvialis apricaria*	4	0	0	0	0	0	0	0	0	0	0	0	4	4
Arctic skua	*Stercorarius parasiticus*	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Great skua	*Stercorarius skua*	0	1	0	0	0	0	1	0	0	0	0	0	2	8
Kittiwake	*Rissa tridactyla*	34	10	26	15	26	31	8	14	24	44	40	26	298	1179
Little gull	*Hydrocoloeus minutus*	0	1	0	0	0	0	0	0	0	0	1	1	3	13
Black-headed gull	*Chroicocephalus ridibundus*	0	0	0	0	20	0	0	1	0	0	0	0	21	31
Common gull	*Larus canus*	5	16	0	0	0	0	1	0	0	1	0	3	26	35
Lesser black-backed gull	*Larus fuscus*	1	13	7	154	18	4	50	2	3	5	5	3	265	813
Herring gull	*Larus argentatus*	0	2	1	1	4	1	6	1	1	10	1	1	29	66
Great black-backed gull	*Larus marinus*	1	0	0	0	0	0	5	9	1	47	11	3	77	148

Species	Scientific Name	Month												Year 2 Total	Grand Total
		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb		
Sandwich tern	*Thallaseus sandvicensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Common tern	*Sterna hirundo*	0	0	1	2	1	0	4	0	0	0	0	0	8	9
Guillemot	*Uria aalge*	126	118	58	7	8	1	49	17	20	186	90	120	800	3517
Razorbill	*Alca torda*	119	16	8	0	0	1	0	40	40	170	38	81	513	1563
Puffin	*Fratercula arctica*	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Feral pigeon	*Columba livia domestica*	0	0	0	1	0	0	0	0	0	0	0	0	1	1
Chaffinch	*Fringilla coelebs*	0	0	0	0	0	0	0	48	0	0	0	0	48	48
Grey seal	*Halichoerus grypus*	0	1	0	0	0	1	0	0	0	1	0	1	4	8
Harbour porpoise	*Phocoena phocoena*	32	25	96	17	26	4	32	12	28	10	15	16	313	575
Total		**325**	**207**	**209**	**204**	**126**	**53**	**208**	**171**	**179**	**487**	**208**	**268**	**2645**	**8938**

Table 9 **Number of objects with no species ID detected during each survey assigned to species groups March 2019 and February 2020. Survey number dates can be observed in Table 4.**

Species group (No ID)	Month												Year 1 Total
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	
Fulmar / gull species	2	0	7	6	1	15	26	2	2	1	2	1	65
Grebe species	1	0	0	0	0	0	0	0	0	0	0	0	1
Skua species excluding great	0	0	0	0	0	0	0	2	0	0	0	0	2
Small gull species	10	2	0	1	0	2	2	0	4	1	0	5	27
Black-backed gull species	0	0	0	1	0	0	0	0	0	0	0	0	1
Large gull species	0	0	0	3	0	7	8	1	0	1	0	0	20
Gull species	1	0	0	1	0	8	3	1	1	0	1	0	16
Arctic / common tern	0	0	3	0	1	6	1	0	0	0	0	0	11
Tern species	0	0	0	0	1	0	0	0	0	0	0	0	1
Tern / small gull species	0	0	0	0	0	2	0	2	0	0	0	0	4
Large auk	25	13	1	0	0	0	2	8	16	44	16	127	252
Auk species	9	4	0	0	0	2	1	3	4	4	2	15	44
Auk / small gull	1	1	0	0	0	0	0	1	0	2	4	11	20
Large auk / diver species	0	0	0	0	0	0	0	0	0	1	3	7	11
Small bird species	0	0	0	0	0	0	0	0	0	1	0	1	2
Seal species	2	0	0	0	0	0	1	2	1	5	1	1	13
Cetacean species	1	0	0	0	0	0	0	0	0	0	0	0	1
Seal / small cetacean species	1	0	0	0	0	1	2	0	0	0	0	1	5
Total	**53**	**20**	**11**	**12**	**3**	**43**	**46**	**22**	**28**	**60**	**29**	**169**	**496**

Table 10 **Number of objects with no species ID detected during each survey assigned to species groups March 2020 and February 2021. Survey dates can be observed in Table 4.**

Species group (No ID)	Month												Year 2 Total	Grand Total
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb		
Diver species	0	0	0	0	0	0	0	0	0	1	0	0	1	1
Fulmar / gull species	1	0	0	0	1	1	5	0	0	1	0	3	12	77
Grebe species	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Skua species excluding great	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Small gull species	0	9	0	0	3	0	1	1	1	0	1	0	16	43
Black-backed gull species	0	0	0	0	0	0	0	0	0	0	0	1	1	2
Large gull species	0	0	0	1	0	0	1	1	0	1	0	0	4	24
Gull species	0	0	1	0	2	0	1	0	0	0	1	0	5	21
Arctic / common tern	0	1	0	4	0	0	0	0	0	0	0	0	5	16
Tern species	0	1	0	0	0	0	0	0	0	0	0	0	1	2
Tern / small gull species	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Large auk	18	1	6	10	0	0	5	0	13	70	16	55	194	446
Auk species	0	0	3	0	0	0	2	0	6	13	2	2	28	72
Auk / small gull	0	6	1	0	0	0	0	0	1	4	4	2	18	38
Large auk / diver species	0	0	0	0	0	0	0	0	0	1	3	1	5	16
Small bird species	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Seal species	1	1	1	2	1	1	1	0	1	1	1	4	15	28
Cetacean species	1	0	0	0	0	0	0	0	0	0	0	0	1	2
Seal / small cetacean species	0	0	2	0	0	0	1	0	0	0	0	1	4	9
Total	**21**	**19**	**14**	**17**	**7**	**2**	**17**	**2**	**22**	**92**	**28**	**69**	**310**	**806**

3.3 Distribution patterns and seasonal abundance

60 Density estimates calculated for the whole survey area, as well as 95% confidence limits, are presented for key species only. Density and population estimates for all species and species groups, as well as measures of standard deviation and CV, are presented in Appendix 1. An explanation of these elements is presented in Table 11.

61 Some of these estimates, for certain diving bird species, were multiplied by a scaling factor as outlined in section 2.6.3 to account for availability bias and give estimates of absolute abundance. The adjusted (absolute) density and abundances provide the best estimate of abundance at the time of survey. These have only been calculated for three bird species: guillemots, razorbills and puffins, and one marine mammal: harbour porpoise. They have not been calculated for any other seabird species which either do not dive or would be submerged for too short a time to warrant calculation of availability bias. No calculation of availability bias was carried out for any other marine mammals due to the low numbers present, and a lack of any information about their diving patterns. Absolute density and abundance estimates can be found in Appendix II and are presented in this section instead of relative density for the relevant key species.

62 Distribution patterns of the most abundant species are presented as density maps, in which a density surface depicts the estimated density of individuals per km². Distributions of less abundant and unidentified species are presented as dot maps only.

63 Anthropogenic activity is presented as dot maps for reference only (Figure 71 and Figure 72).

Table 11 Terms used in density and abundance analysis

Term	Definition
Density estimate *(birds/km^2)*	The mean number of birds (or animals) per square km surveyed over the whole area (VE site plus 4km buffer)
Population estimate *(number)*	The mean number of birds (or animals) estimated to exist across the whole survey area (VE site plus 4km buffer)
95% confidence intervals or 'limits' of population *(CI)*	A measure of uncertainty in the mean value. If the analysis was repeated, 95% of the time the mean population estimate would fall within this upper and lower boundary. The smaller the relative CI range, the more confident we can be that the mean estimate is an accurate reflection of the true population size.
Standard deviation *(SD)* of population estimate	The amount of variation or dispersion of a set of values. A low SD indicates that the bootstrap values tend to be close to the mean of the set.
CV (%)	The coefficient of variation is a standard measure that describes the dispersion of data points around the mean. The lower the CV the more precise the estimate. It is calculated as the SD / mean.
Relative abundance	In the case of diving birds and mammals, this is the estimated population size based on animals recorded on or above the sea surface and does not account for any that may be diving and thus submerged at the time of survey.
Absolute abundance	The most accurate estimate of population size. In the case of diving birds and mammals, this includes an estimate for the number that are believed to be submerged at the time of survey.

3.3.1 All birds

64 The total number of birds recorded across the survey programme, including those partially and fully identified, are presented below (Table 12; Figure 4), whilst the distribution and density of all birds are presented in Figure 5 and Figure 6. In both years, avian abundance increased during the wintering periods, with marked peaks in March 2019 and February 2020. Generally, fewer birds were recorded during the breeding season in the summer, particularly in May 2019 and August 2020.

65 The monthly density maps indicate birds were present across the whole survey area. Generally, elevated densities occurred during the winter months, with birds widespread across the site. The highest densities were recorded during the February 2020 survey, particularly in the south of the survey area.

Table 12 Number of birds recorded between March 2019 and February 2021

Survey	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Year 1 Total
All birds	1406	552	105	374	208	315	202	156	391	609	274	1912	6504
Survey	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Year 2 Total**
All birds	312	199	124	202	106	49	191	161	172	567	220	315	2618

Figure 4 Number of birds recorded between March 2019 and February 2021

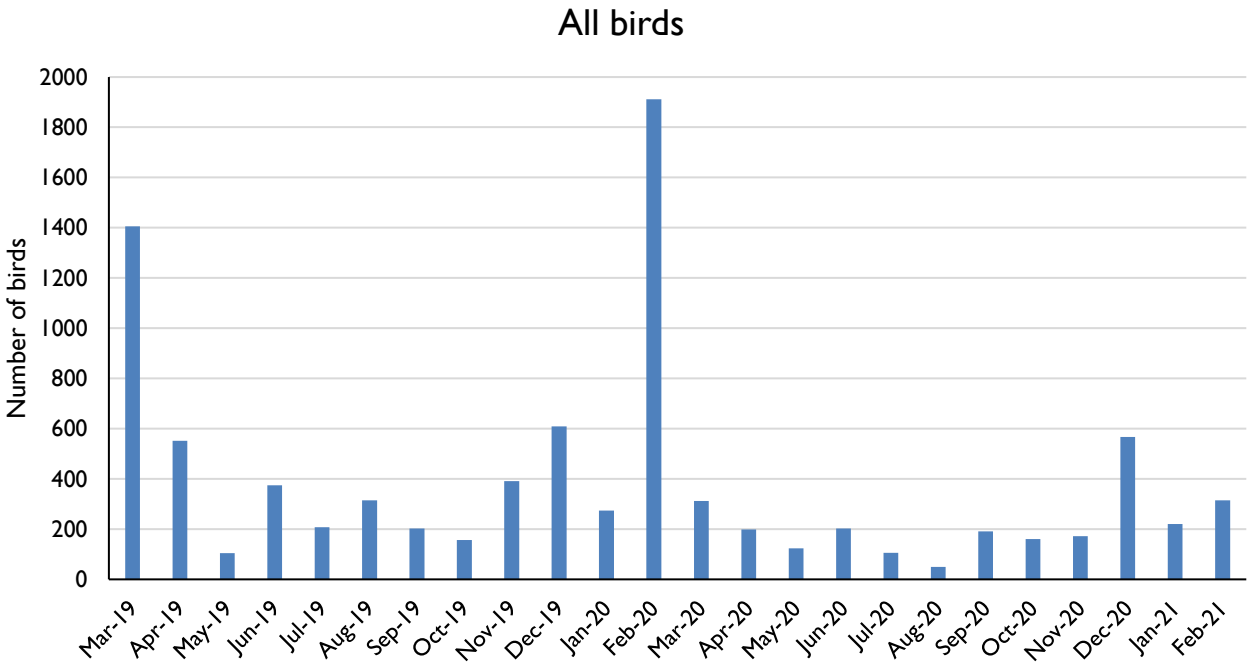


Figure 5 **Density of all birds (number/km²) and number of detections per segment between March 2019 and February 2020**

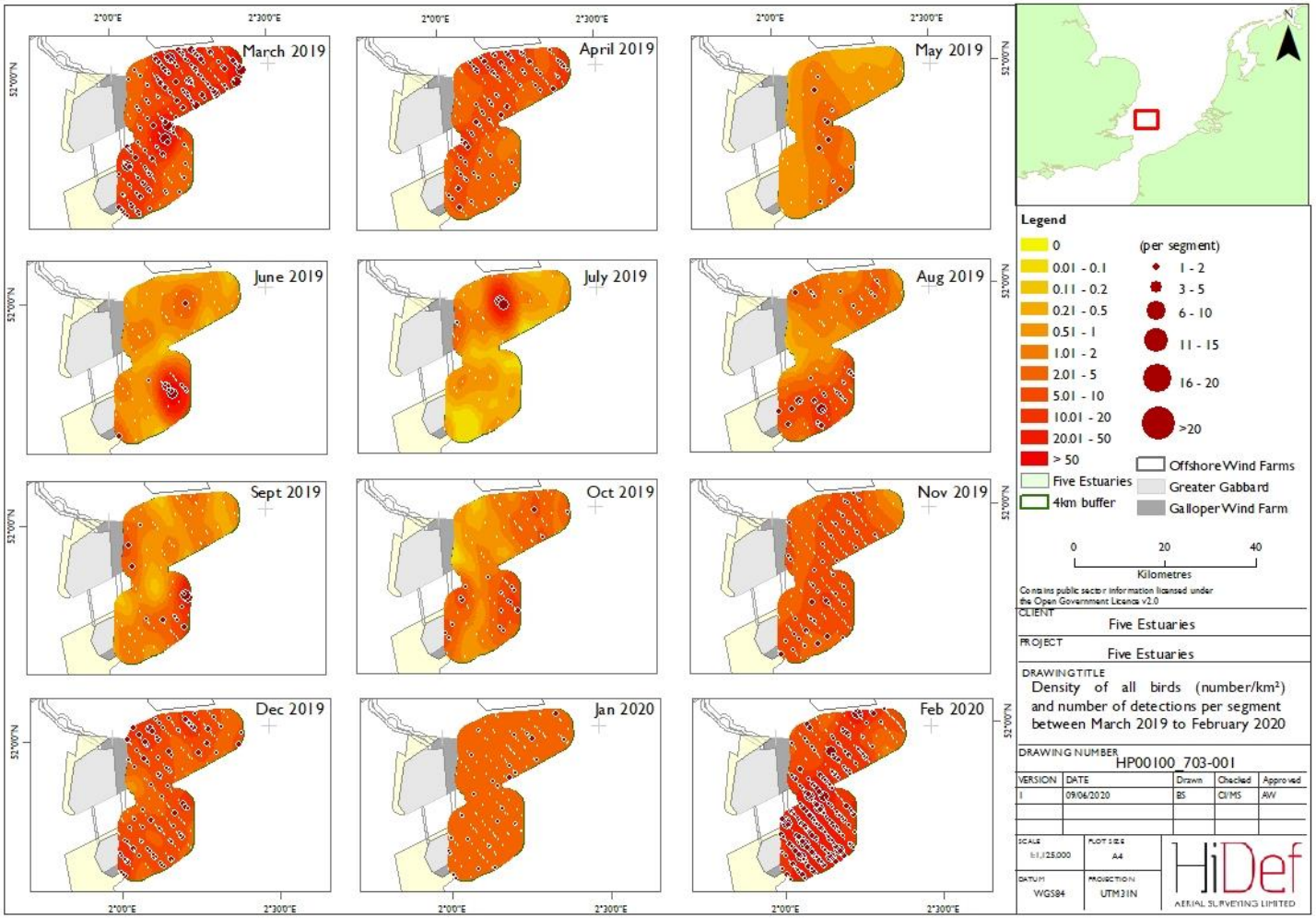
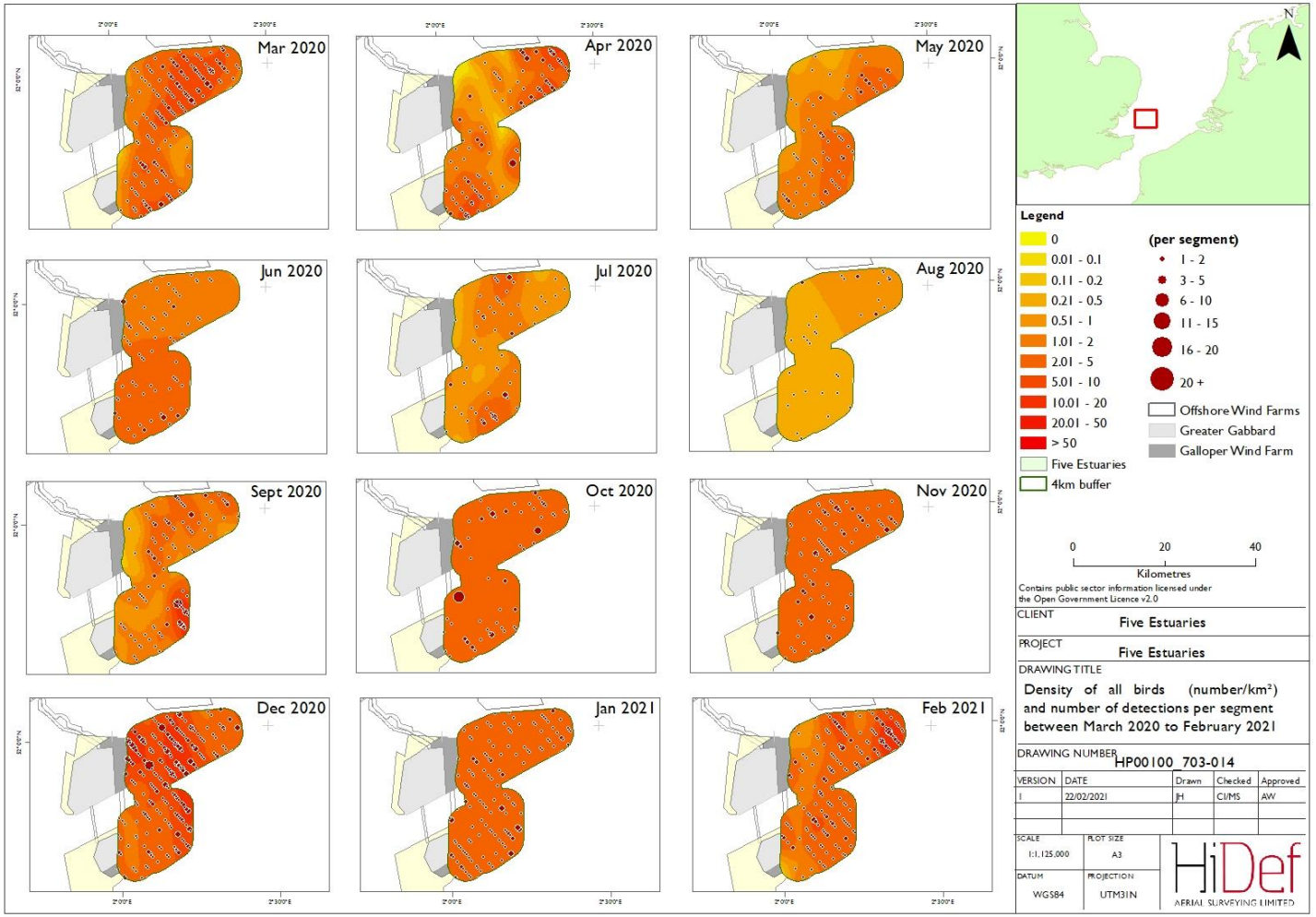


Figure 6 **Density of all birds (number/km²) and number of detections per segment between March 2020 and February 2021**



3.3.2 Fulmar

66 Fulmars were most abundant in the breeding season, with few birds recorded throughout the winter. Considerably more fulmars were observed in the first year compared to the second (Table 13; Figure 8).

67 High densities of birds were estimated across the site during the 2019 breeding season, reaching a peak of 0.44 birds/km² in August 2019 (Figure 8), and equating to a population estimate of 265 birds (±95% CI 81 – 484). From October 2019 to April 2020, very low-density estimates were recorded, with estimates no higher than 0.05 birds/km². Moderate to low densities of fulmars were estimated for the second year, ranging between 0 and 0.16 birds/km². This equated to a peak population estimate of 96 birds (±95% CI 27 - 188) was reached in the 2020 breeding season.

68 During months with very low observations, as experienced between October and February in both years, it was difficult to draw any conclusions regarding distributions (Figure 9; Figure 10). However, animals were generally located in the east of the survey area. In the summer months, such as in June, August and September 2019 and July 2020, high densities of fulmar were concentrated in the south-east.

69 Across the two-year period, only 28% of birds were observed flying (Table 14). No obvious patterns in flight direction could be determined in both years (Figure 11; Figure 12).

Table 13 Number of fulmars recorded between March 2019 and February 2021

Survey	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Year 1 Total
Fulmar	26	5	16	17	7	39	37	2	2	0	3	1	155
Survey	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Year 2 Total**
Fulmar	2	0	9	3	14	4	4	0	1	0	0	1	38

Figure 7 Number of fulmars recorded between March 2019 and February 2021

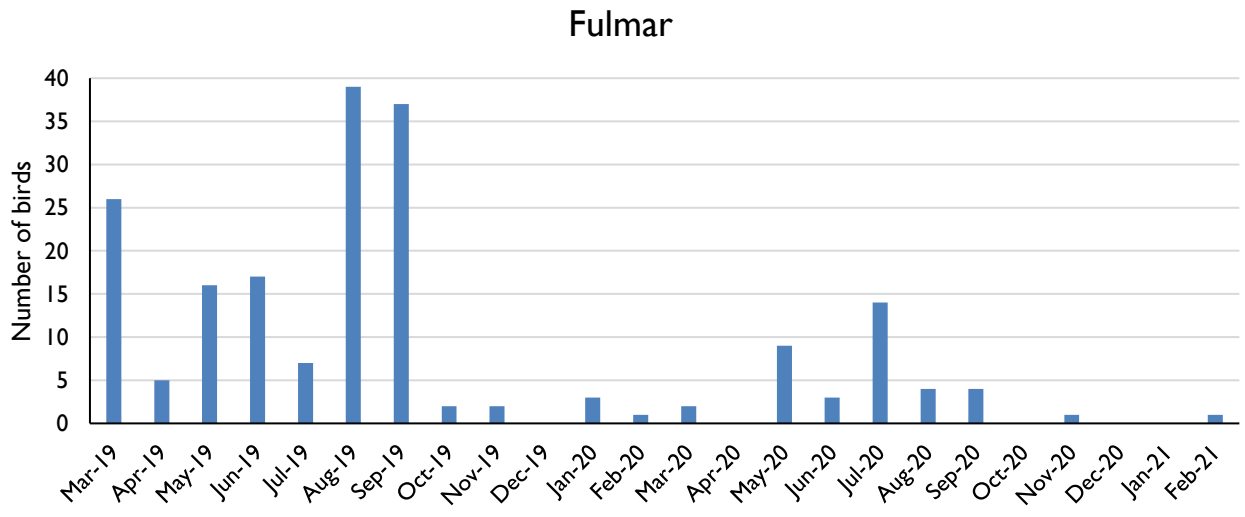


Figure 8 **Fulmar density estimates with lower and upper 95% confidence intervals between March 2019 and February 2021**

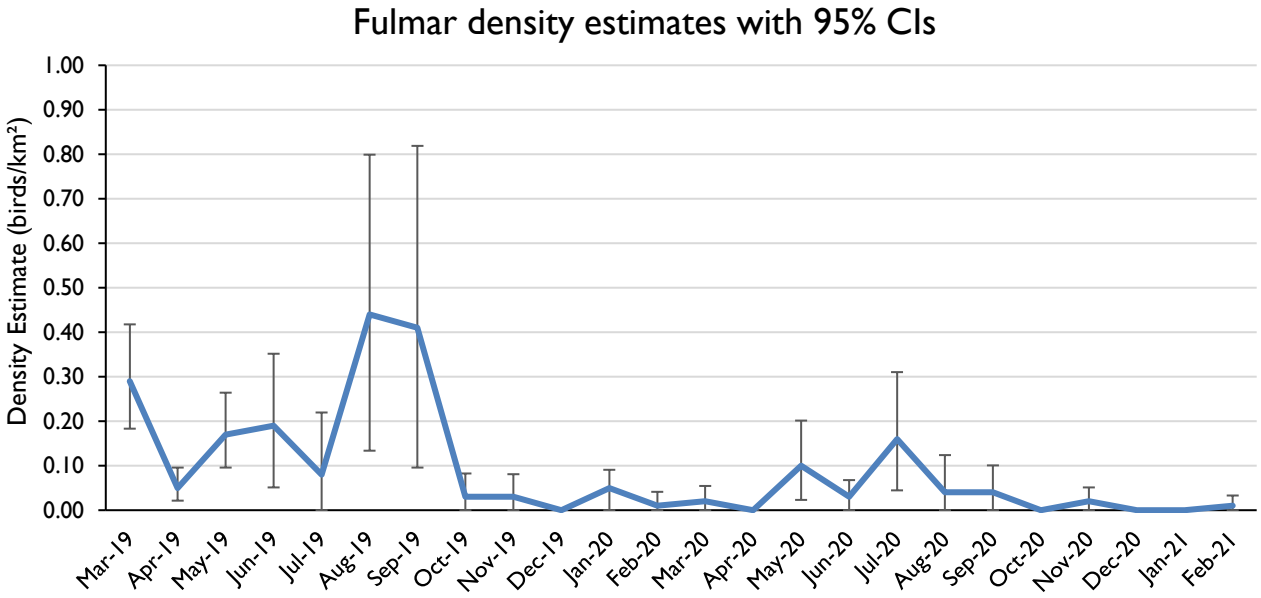


Figure 9 **Density of fulmars (number/km²) and number of detections per segment between March 2019 and February 2020**

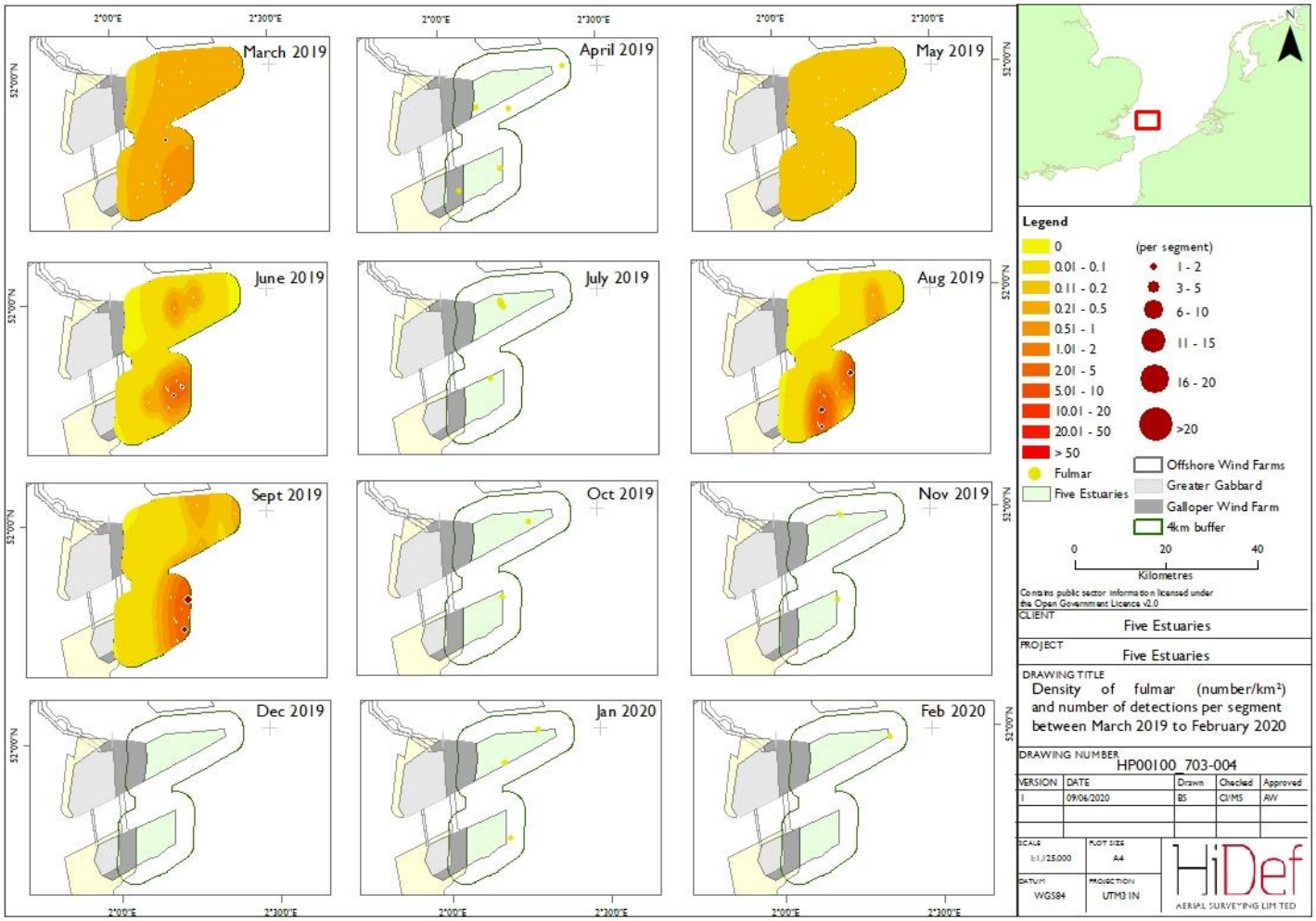


Figure 10 **Density of fulmars (number/km²) and number of detections per segment between March 2020 and February 2021**

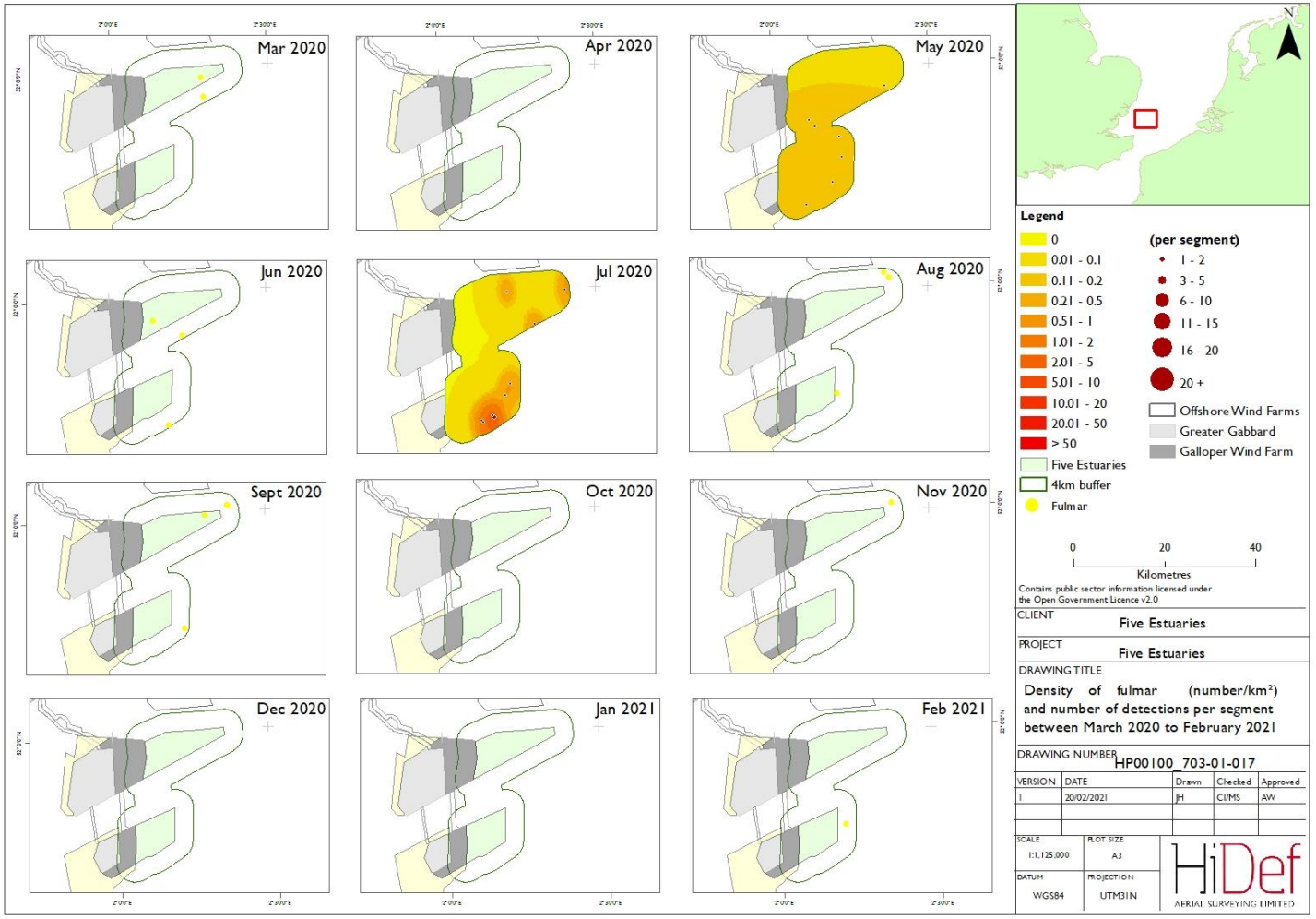


Table 14 Summary of fulmar behaviours between March 2019 and February 2020

Survey date	Number recorded diving	Number recorded flying	Number recorded landing	Number recorded sitting	Number recorded taking off	% Flying	Total
Mar-19	0	12	0	14	0	46%	26
Apr-19	0	5	0	0	0	100%	5
May-19	0	5	0	11	0	31%	16
Jun-19	0	4	0	13	0	24%	17
Jul-19	0	5	0	2	0	71%	7
Aug-19	0	4	0	35	0	10%	39
Sep-19	0	2	0	35	0	5%	37
Oct-19	0	0	0	2	0	0%	2
Nov-19	0	1	0	1	0	50%	2
Dec-19	0	0	0	0	0	0%	0
Jan-20	0	2	0	1	0	67%	3
Feb-20	0	0	0	1	0	0%	1
Mar-20	0	1	0	1	0	50%	2
Apr-20	0	0	0	0	0	0%	0
May-20	0	2	0	7	0	22%	9
Jun-20	0	2	0	1	0	67%	3
Jul-20	0	8	0	6	0	57%	14
Aug-20	0	0	0	4	0	0%	4
Sep-20	0	1	0	3	0	25%	4
Oct-20	0	0	0	0	0	0%	0
Nov-20	0	0	0	1	0	0%	1
Dec-20	0	0	0	0	0	0%	0
Jan-21	0	0	0	0	0	0%	0
Mar-19	0	1	0	0	0	100%	1
Total	**0**	**55**	**0**	**138**	**0**	**28%**	**193**

Figure 11 Flying direction of fulmars observed between March 2019 and February 2020

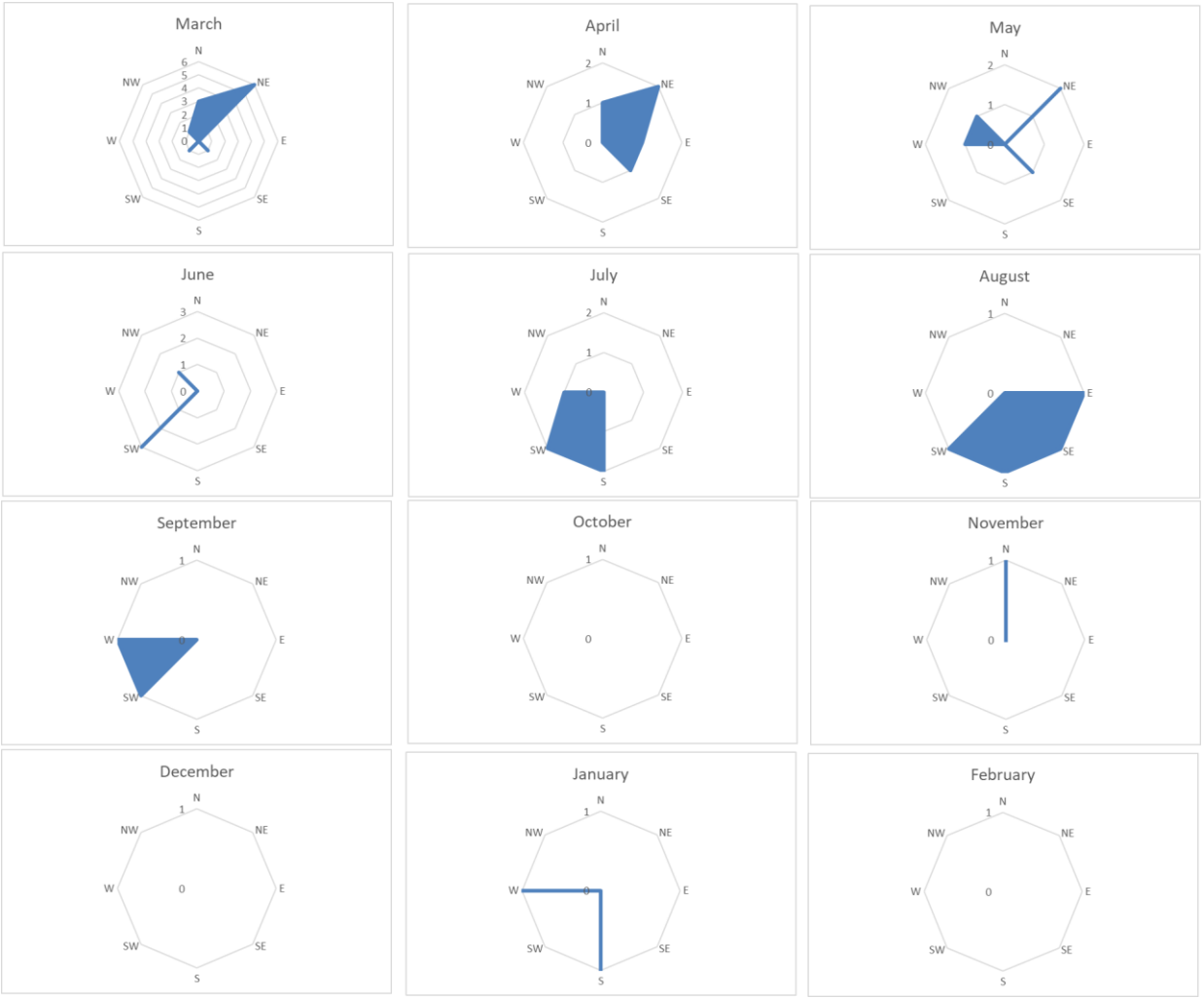
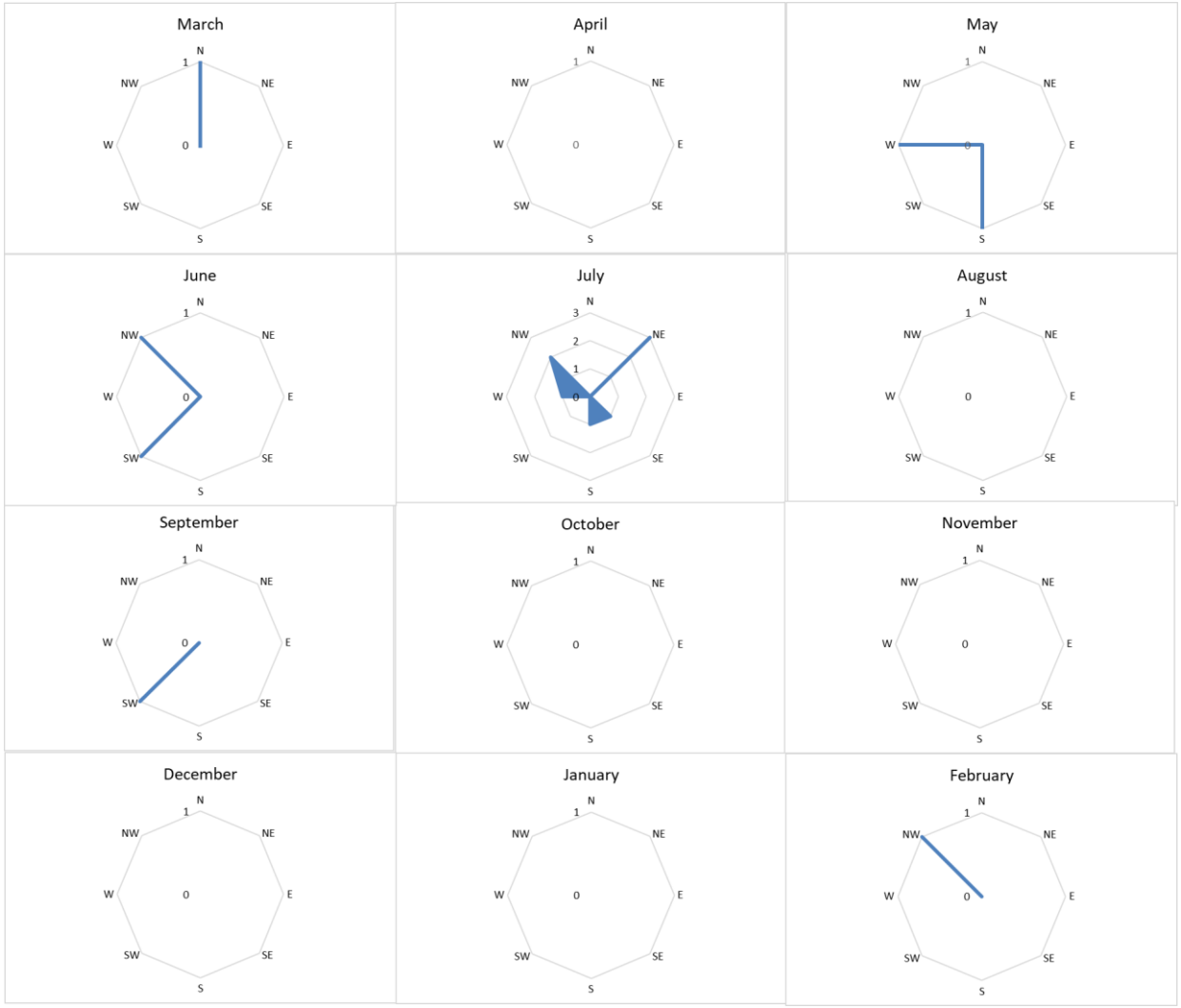


Figure 12 Flying direction of fulmars observed between March 2020 and February 2021



3.3.3 Gannet

70 Gannet numbers fluctuated over the two-year period, with birds present across both breeding seasons. Approximately three times the number of gannets were present in the first year compared to the second. Records peaked in November in each year, with very few birds remaining through the winter and no birds recorded in January or March 2020 (Table 15; Figure 13). As such, density estimates varied greatly (Figure 14). Peak density reached 2.26 birds/km² in November 2019, equating to 1,370 birds (±95% CI 1,041 – 1,741). This compared to a second-year peak of 1.01 birds/km² in November 2020, equating to a population estimate of 614 birds (±95% CI 351 – 907).

71 Gannet distribution varied between months, although selection towards the east of the study site was observed in several months, such as March, August and October 2019 and September and November 2020 (Figure 15; Figure 16). There were no clear patterns in distribution April, May and June 2019 and August 2020. Fewer birds were present in the west buffer, which overlaps with the active Galloper Wind Farm site. In several months, such as November 2019 and October 2020, gannets were widely distributed throughout the survey region.

72 Of the birds that could be aged, the majority (81%) were recorded as adults, with juvenile birds making up only 2% of all aged birds (Table 16). Proportions of immature birds increased in autumn, comprising 52% of aged birds in August 2019 and 30% of aged birds in September 2020. The behaviour of gannets varied, with on average, 42% and 57% of birds recorded flying and sitting respectively across the entire study period (Table 17).

73 Flight direction varied, with many birds recorded flying eastwards in Year 1, particularly in August and November 2019 (Figure 17). This was not the case in Year 2 and no clear patterns in flight direction were present for several months, although movement northwards by many birds was recorded in October and November 2020 (Figure 18)

Table 15 Number of gannets recorded between March 2019 and February 2021

Survey	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Year 1 Total
Gannet	75	27	3	53	13	100	20	32	137	2	0	50	512
Survey	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Year 2 Total**
Gannet	0	2	1	4	9	6	40	26	61	10	2	8	169

Figure 13 **Number of gannets recorded between March 2019 and February 2021**

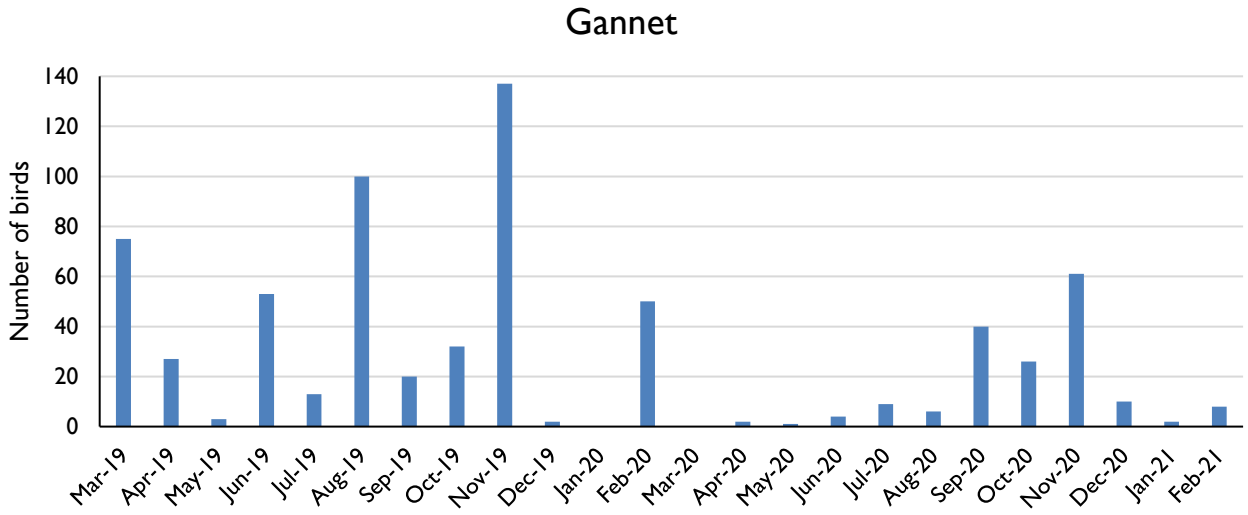


Figure 14 **Gannet density with lower and upper 95% confidence intervals between March 2019 and February 2021**

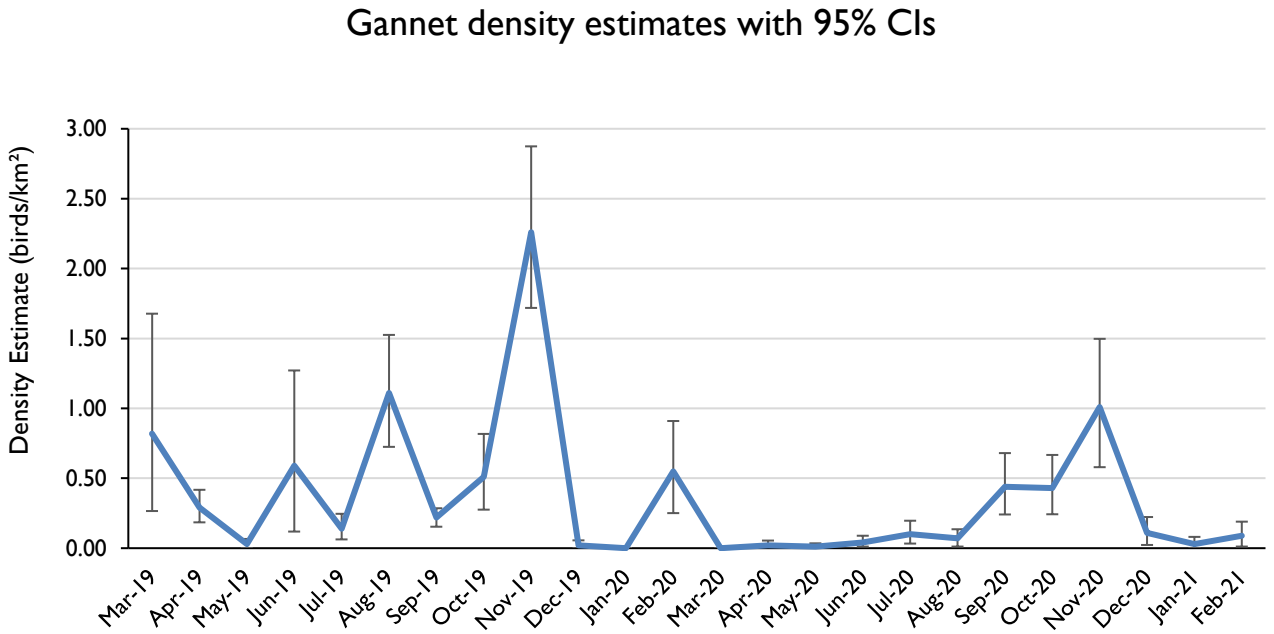


Figure 15 **Density of gannets (number/km²) and number of detections per segment between March 2019 and February 2020**

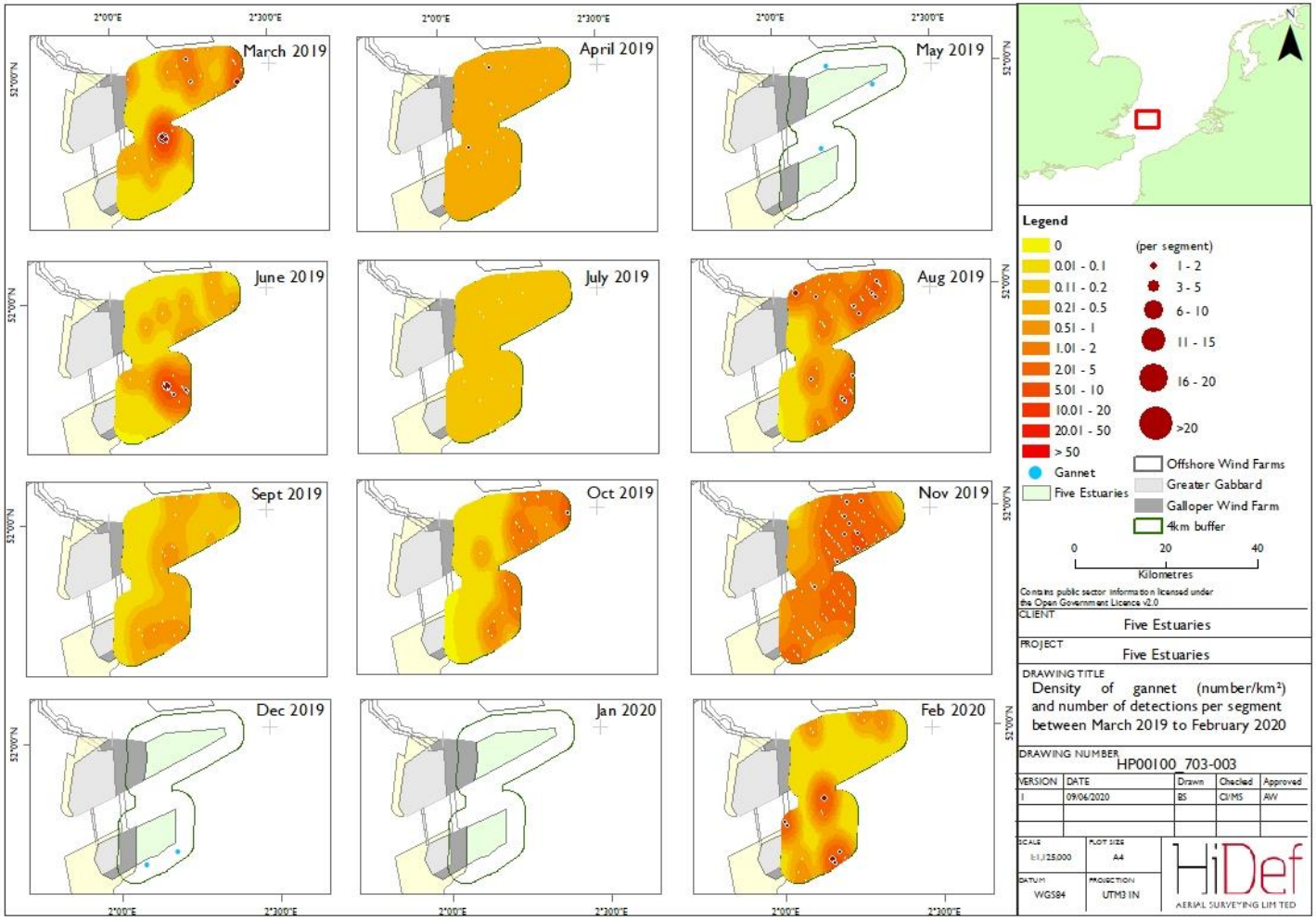


Figure 16 **Density of gannets (number/km²) and number of detections per segment between March 2020 and February 2021**

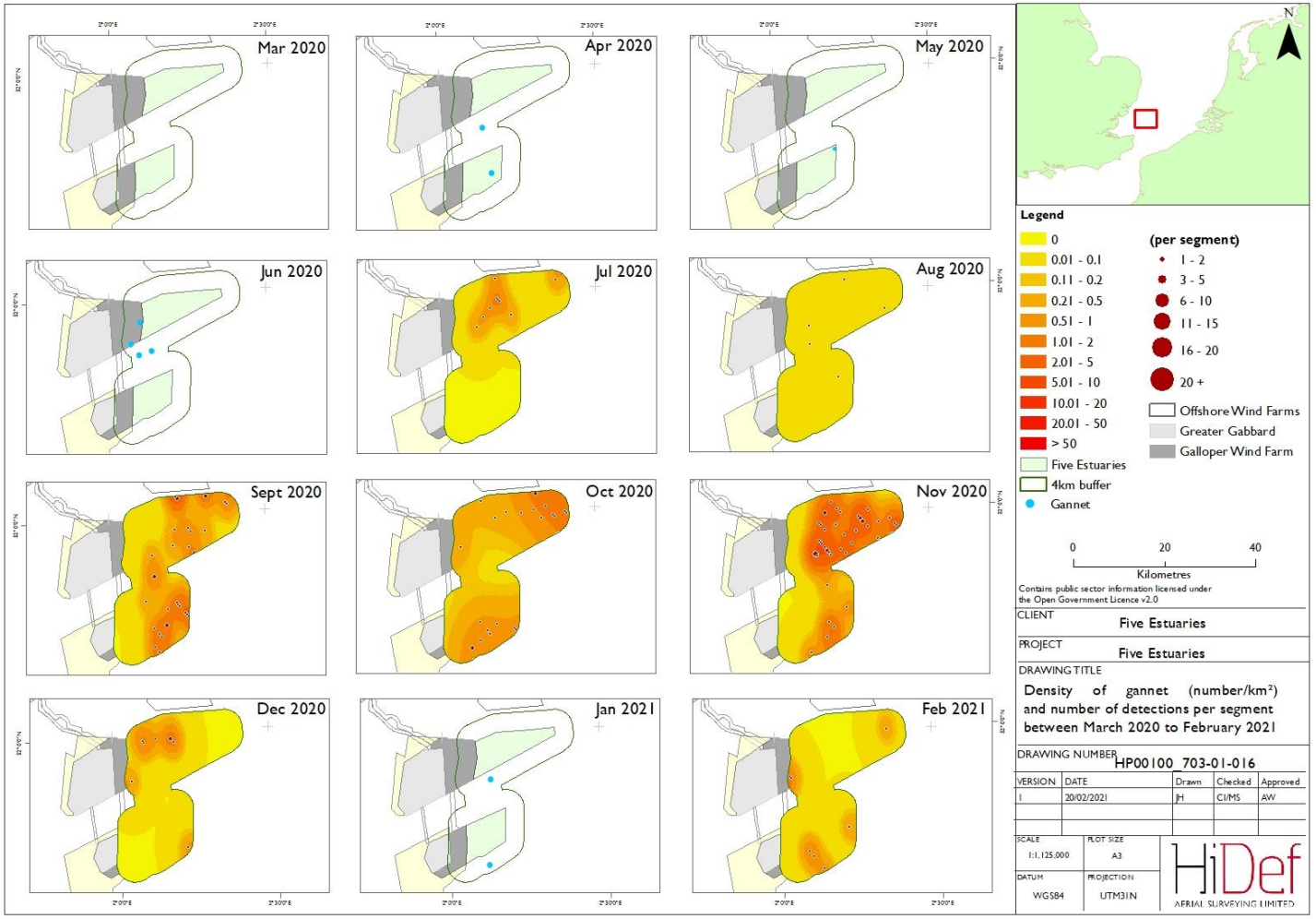


Table 16 Summary of gannet ages between March 2019 and February 2021

Gannet	Number recorded as adult	Number recorded as immature	Number recorded as juvenile	Number recorded as unknown	% Adults (from aged birds)	Total
Mar-19	14	0	0	61	100%	75
Apr-19	15	0	0	12	100%	27
May-19	2	0	0	1	100%	3
Jun-19	8	2	0	43	80%	53
Jul-19	0	1	0	12	0%	13
Aug-19	26	28	0	46	48%	100
Sep-19	2	3	4	11	22%	20
Oct-19	20	3	0	9	87%	32
Nov-19	69	0	0	68	100%	137
Dec-19	1	0	0	1	100%	2
Jan-20	0	0	0	0	-	0
Feb-20	15	0	0	35	100%	50
Mar-20	0	0	0	0	-	0
Apr-20	2	0	0	0	100%	2
May-20	0	1	0	0	0%	1
Jun-20	0	1	0	3	0%	4
Jul-20	2	3	0	4	40%	9
Aug-20	1	1	1	3	33%	6
Sep-20	9	4	0	27	69%	40
Oct-20	15	5	0	6	75%	26
Nov-20	44	1	0	16	98%	61
Dec-20	4	0	0	6	100%	10
Jan-21	2	0	0	0	100%	2
Feb-21	8	0	0	0	100%	8
Total	**259**	**53**	**5**	**364**	**82%**	**681**

Table 17 Summary of gannet behaviours between March 2019 and February 2021

Survey date	Number recorded diving	Number recorded flying	Number recorded landing	Number recorded sitting	Number recorded taking off	% Flying	Total
Mar-19	0	18	0	55	2	24%	75
Apr-19	0	15	0	12	0	56%	27
May-19	0	2	0	1	0	67%	3
Jun-19	0	10	0	43	0	19%	53
Jul-19	0	1	0	12	0	8%	13
Aug-19	0	49	0	49	2	49%	100
Sep-19	0	10	0	10	0	50%	20
Oct-19	0	20	0	12	0	63%	32
Nov-19	0	44	0	93	0	32%	137
Dec-19	0	1	0	1	0	50%	2
Jan-20	0	0	0	0	0	0%	0
Feb-20	0	15	0	34	1	30%	50
Mar-20	0	0	0	0	0	0%	0
Apr-20	0	2	0	0	0	100%	2
May-20	0	1	0	0	0	100%	1
Jun-20	0	1	0	3	0	25%	4
Jul-20	0	5	0	4	0	56%	9
Aug-20	0	3	0	3	0	50%	6
Sep-20	0	11	0	29	0	28%	40
Oct-20	0	20	0	6	0	77%	26
Nov-20	0	45	0	16	0	74%	61
Dec-20	0	4	0	6	0	40%	10
Jan-21	0	2	0	0	0	100%	2
Feb-21	0	8	0	0	0	100%	8
Total	**0**	**287**	**0**	**389**	**5**	**42%**	**681**

Figure 17 Flying direction of gannets observed between March 2019 and February 2020

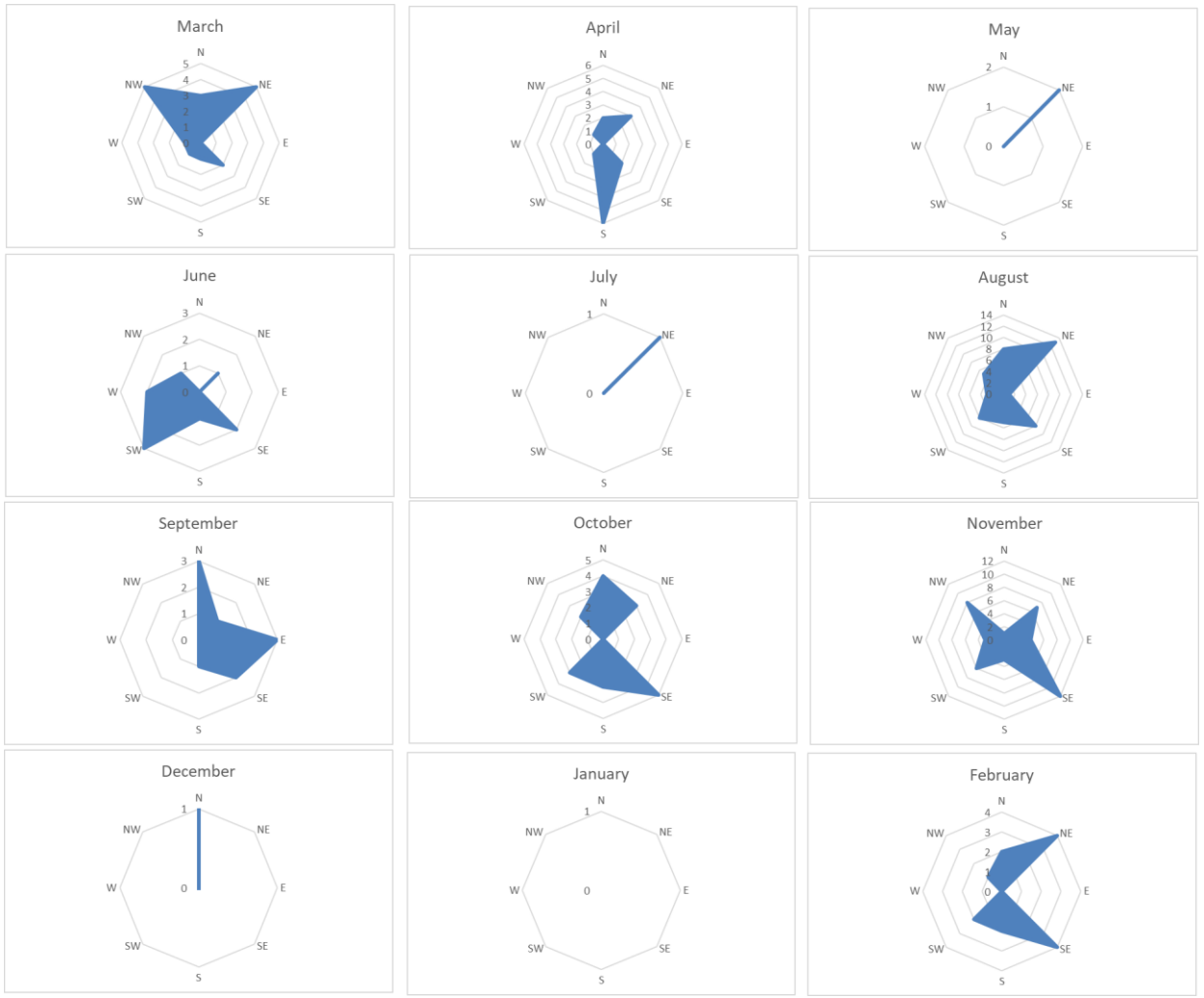
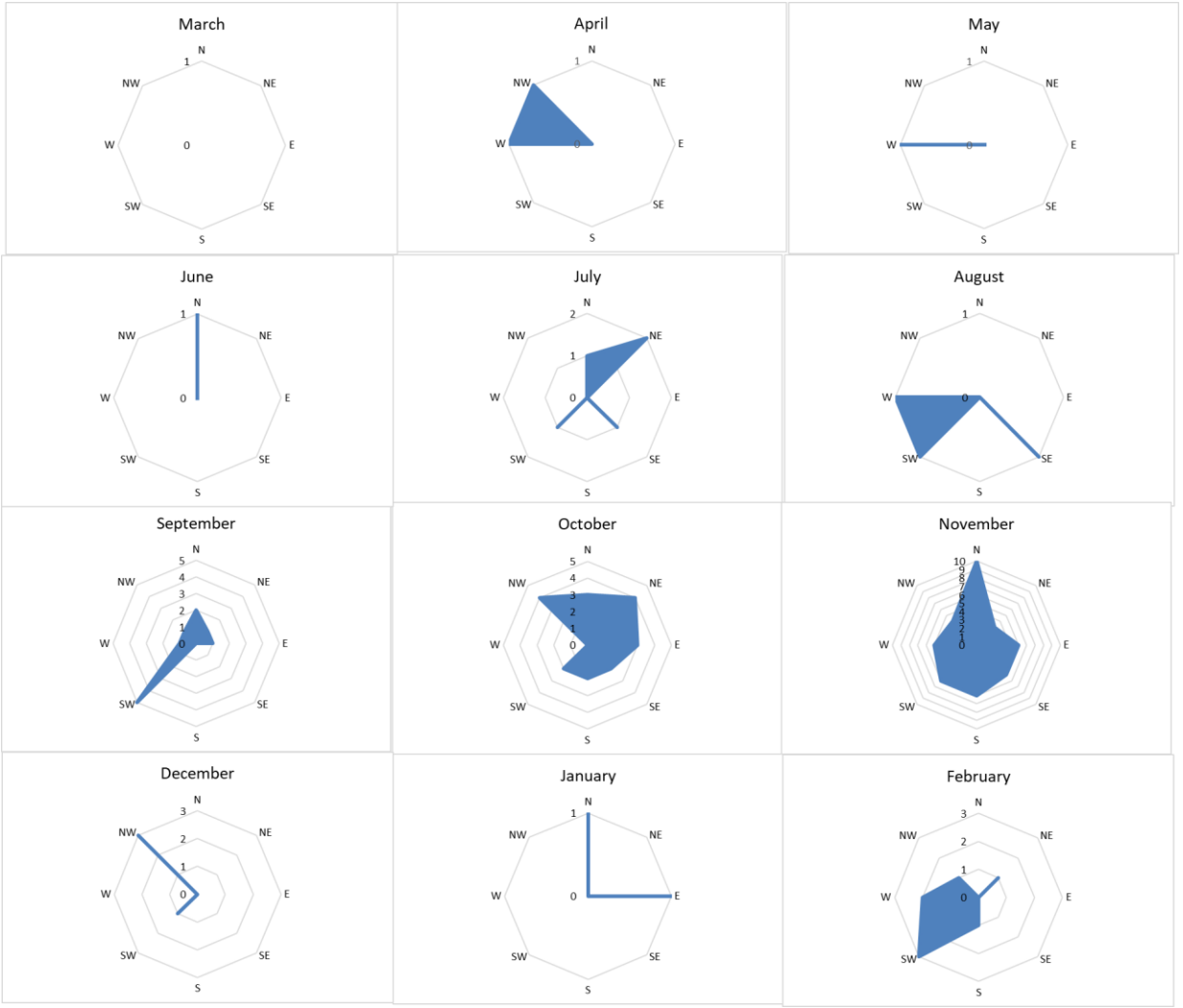


Figure 18 Flying direction of gannets observed between March 2020 and February 2021



3.3.4 Kittiwake

74 Kittiwakes were generally most abundant in the winter, bar spring 2019. Observations of kittiwakes were notably high in March 2019 (366 birds) compared to the rest of the study period, with moderate to low records present throughout the remainder of the surveys (Table 18; Figure 19). From May 2019 to February 2021, no more than 84 kittiwakes were recorded in the survey area. Approximately three times as many birds were recorded in Year 1 compared to Year 2.

75 Density and abundance estimates fluctuated throughout the survey period, ranging from 4.05 birds/km^2 in March 2019, equating to 2,457 birds (±95% CI 1,797 – 3,224), to 0.09 birds/km^2 in September 2020, equating to 54 birds (±95% CI 20 – 93) (Figure 20). Between March and October 2020, estimated density was low, ranging between 0.09 and 0.38 birds/km^2. This equated to an estimated abundance of between 54 birds (±95% CI 20 – 93) and 229 (±95% CI 122 – 345). Winter densities peaked at 0.96 birds/km^2 in November 2019 and 0.67 birds/km^2 in January 2021.

76 Kittiwakes were widespread throughout the survey area from March to June in both years, with no clear patterns in distribution (Figure 21; Figure 22). The species was concentrated in the north-west of the survey area in July in both 2019 and 2020. Birds seemed to be distributed to the east of the survey area in December 2020.

77 Immature birds accounted for 11% of aged records, with the majority of young individuals present in the spring of 2019. Very few juvenile birds were present, accounting for less than 1% of all aged birds (Table 19).

78 A higher proportion of birds were recorded as flying during Year 2 compared to Year 1, with 58% and 44% flying respectively (Table 20). In Year 1, the majority of birds were recorded sitting in the survey area. Large numbers of kittiwakes were observed flying westwards in March 2019 and between November 2019 and February 2020 (Figure 23; Figure 24). In Year 2 this was less pronounced, with a number of birds flying eastwards in May, July and August 2020 as well as in January 2021.

Table 18 Number of kittiwakes recorded between March 2019 and February 2021

Survey	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Year 1 Total
Kittiwake	366	109	52	37	9	14	33	7	58	83	29	84	881
Survey	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Year 2 Total**
Kittiwake	34	10	26	15	26	31	8	14	24	44	40	26	298

Figure 19 **Number of kittiwakes recorded between March 2019 and February 2021**

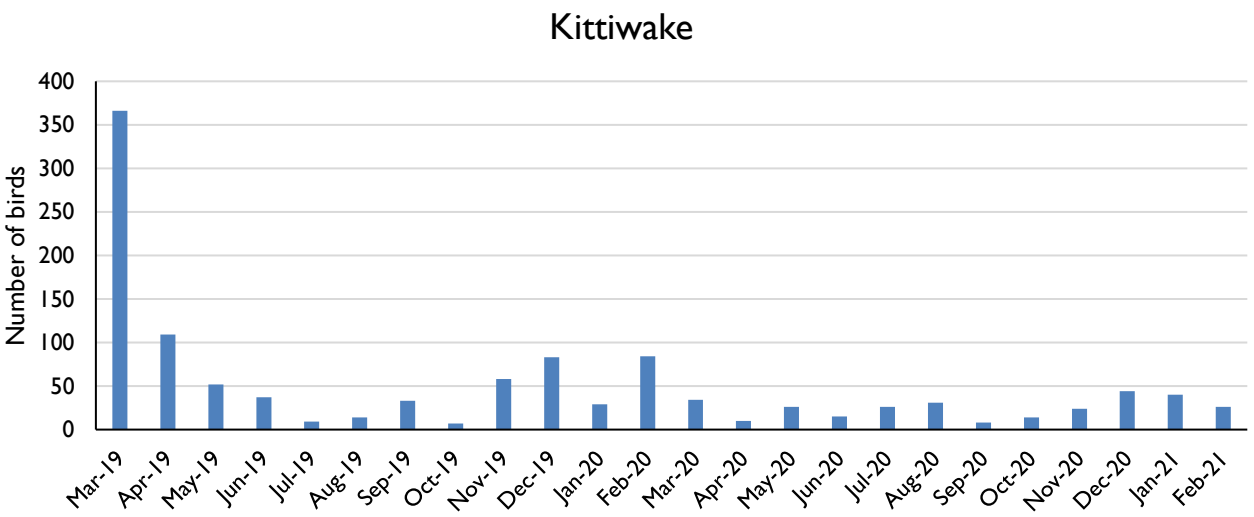


Figure 20 **Kittiwake density estimates with lower and upper 95% confidence intervals between March 2019 and February 2021**

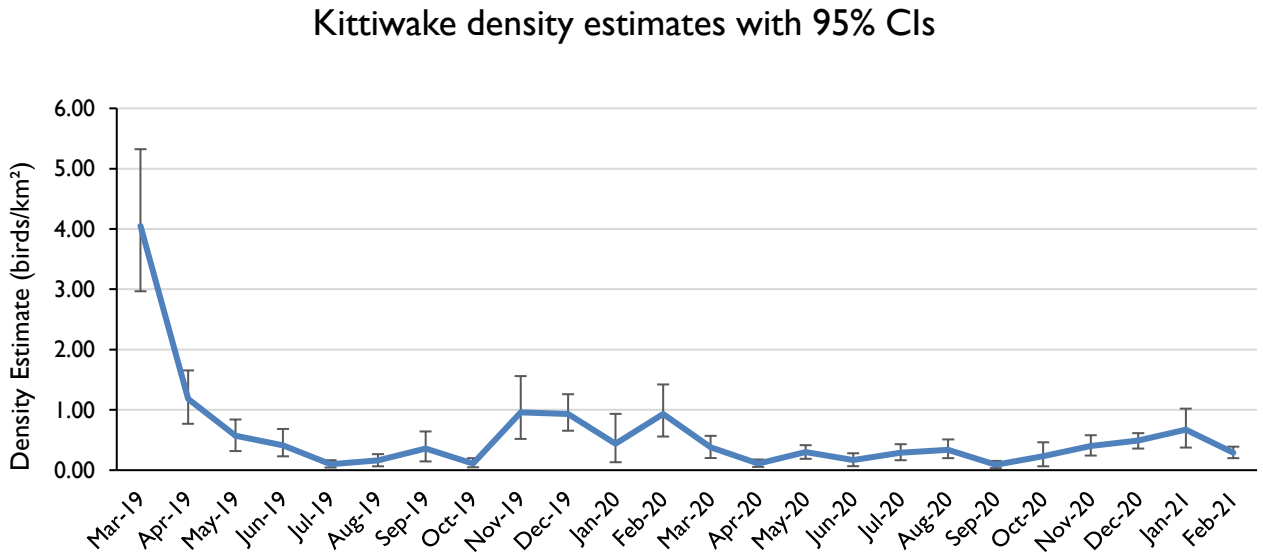


Figure 21 **Density of kittiwakes (number/km²) and number of detections per segment between March 2019 and February 2020**

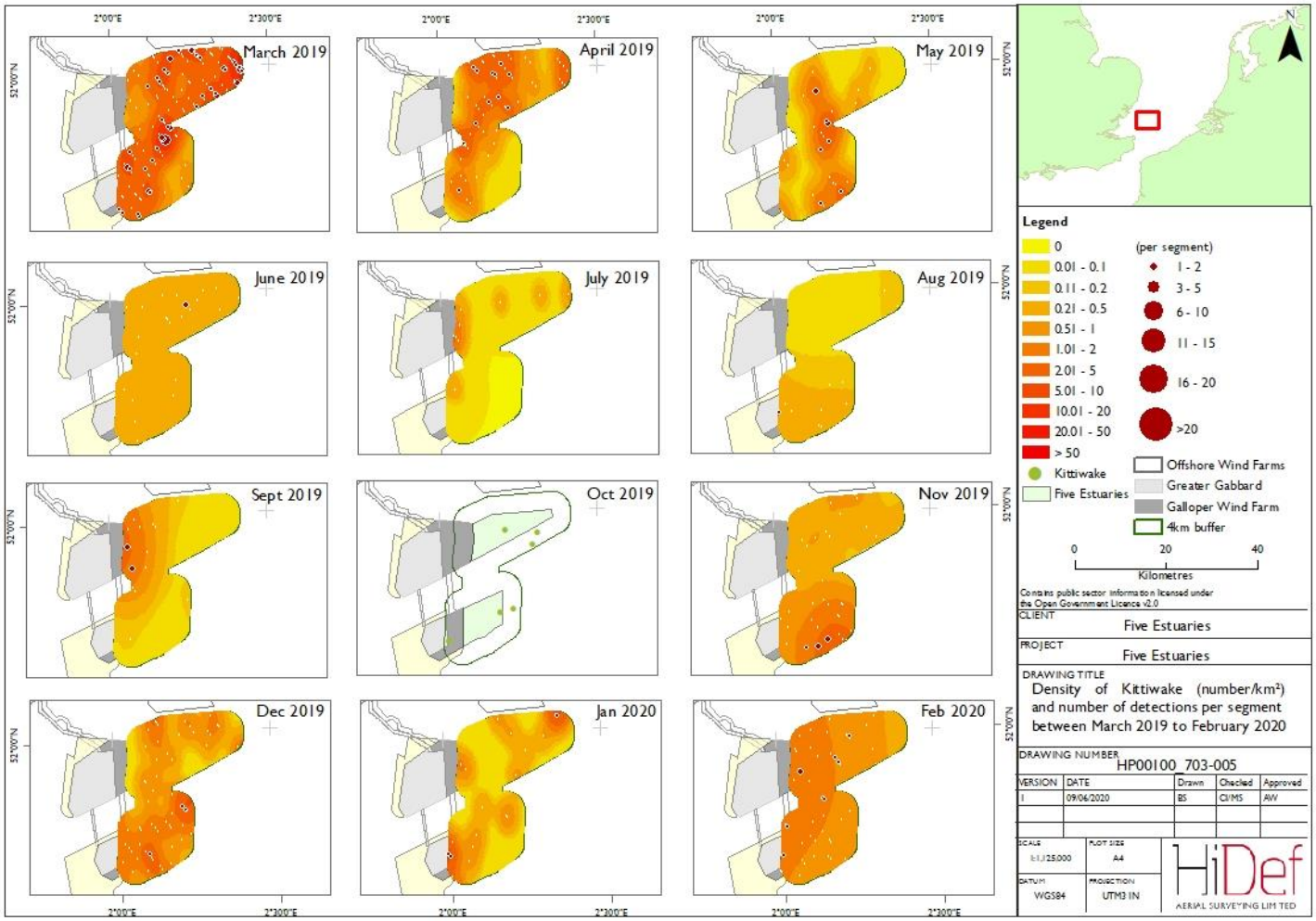


Figure 22 **Density of kittiwakes (number/km²) and number of detections per segment between March 2020 and February 2021**

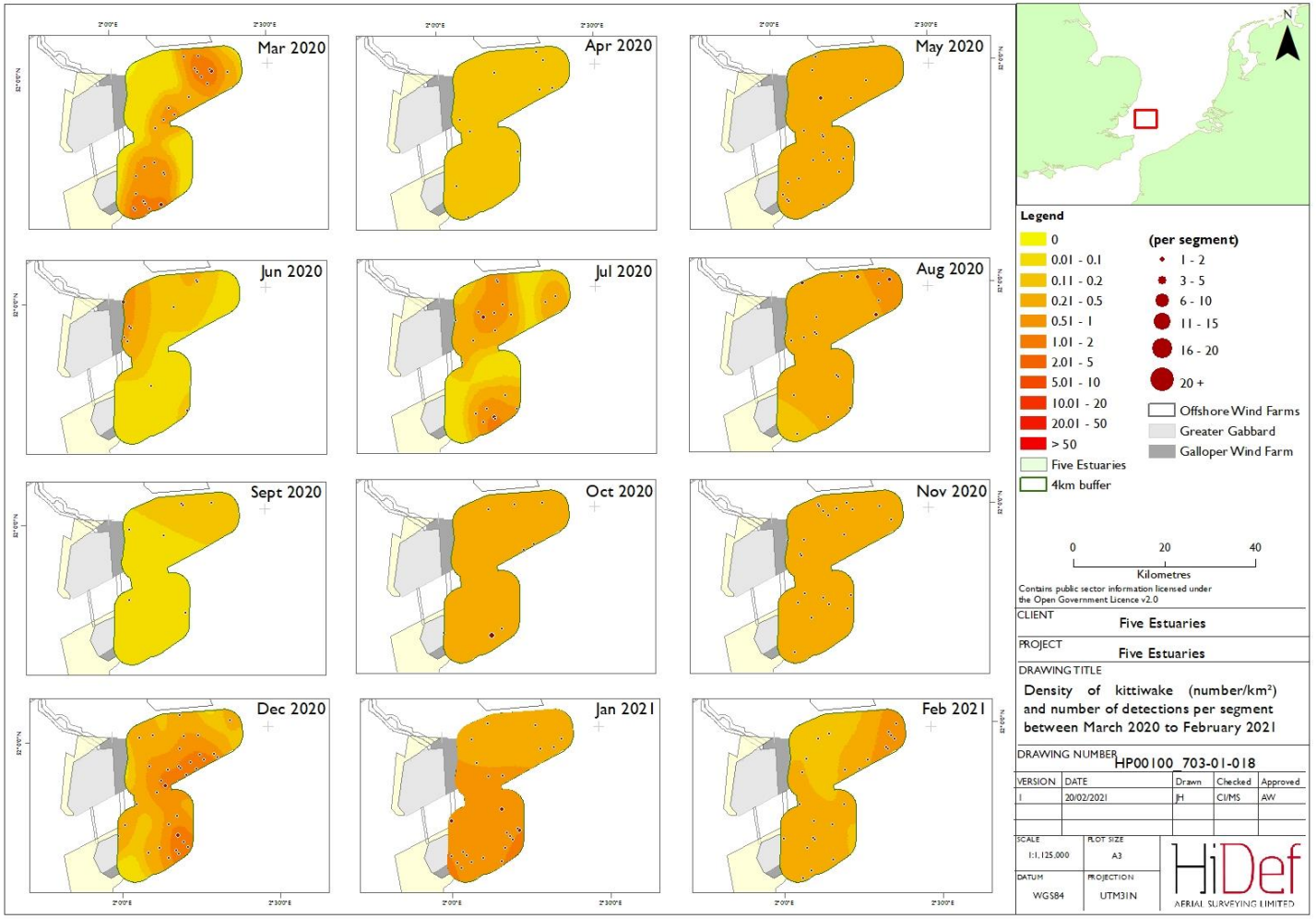


Table 19 Summary of kittiwake ages between March 2019 and February 2021

Kittiwake	Number recorded as adult	Number recorded as immature	Number recorded as juvenile	Number recorded as unknown	% Adults (from aged birds)	Total
Mar-19	87	19	1	259	81%	366
Apr-19	22	16	0	71	58%	109
May-19	7	8	0	37	47%	52
Jun-19	18	2	0	17	90%	37
Jul-19	5	0	0	4	100%	9
Aug-19	1	0	0	13	100%	14
Sep-19	4	0	1	28	80%	33
Oct-19	4	0	0	3	100%	7
Nov-19	27	1	1	29	93%	58
Dec-19	56	0	0	27	100%	83
Jan-20	26	1	0	2	96%	29
Feb-20	35	0	0	49	100%	84
Mar-20	11	2	0	21	85%	34
Apr-20	7	1	0	2	88%	10
May-20	19	0	0	7	100%	26
Jun-20	11	1	0	3	92%	15
Jul-20	11	0	0	15	100%	26
Aug-20	9	0	1	21	90%	31
Sep-20	1	0	0	7	100%	8
Oct-20	3	0	1	10	75%	14
Nov-20	17	1	2	4	85%	24
Dec-20	25	1	0	18	96%	44
Jan-21	23	1	0	16	96%	40
Feb-21	16	2	0	8	89%	26
Total	**445**	**56**	**7**	**671**	**88%**	**1179**

Table 20 Summary of kittiwake behaviours between March 2019 and February 2020

Survey date	Number recorded diving	Number recorded flying	Number recorded landing	Number recorded sitting	Number recorded taking off	% Flying	Total
Mar-19	0	146	0	219	1	40%	366
Apr-19	0	38	0	71	0	35%	109
May-19	0	15	0	37	0	29%	52
Jun-19	0	20	0	17	0	54%	37
Jul-19	0	6	0	3	0	67%	9
Aug-19	0	1	0	13	0	7%	14
Sep-19	0	6	0	27	0	18%	33
Oct-19	0	4	0	3	0	57%	7
Nov-19	0	27	0	31	0	47%	58
Dec-19	0	57	0	26	0	69%	83
Jan-20	0	28	0	1	0	97%	29
Feb-20	0	37	0	47	0	44%	84
Mar-20	0	14	0	20	0	41%	34
Apr-20	0	8	0	2	0	80%	10
May-20	0	17	0	9	0	65%	26
Jun-20	0	12	0	3	0	80%	15
Jul-20	0	12	0	14	0	46%	26
Aug-20	0	9	0	22	0	29%	31
Sep-20	0	1	0	7	0	13%	8
Oct-20	0	4	0	10	0	29%	14
Nov-20	0	21	0	3	0	88%	24
Dec-20	0	26	0	18	0	59%	44
Jan-21	0	26	0	13	0	65%	40
Feb-21	0	23	0	3	0	88%	26
Total	**0**	**558**	**0**	**619**	**1**	**47%**	**1179**

Figure 23 Flying direction of kittiwakes observed between March 2019 and February 2020

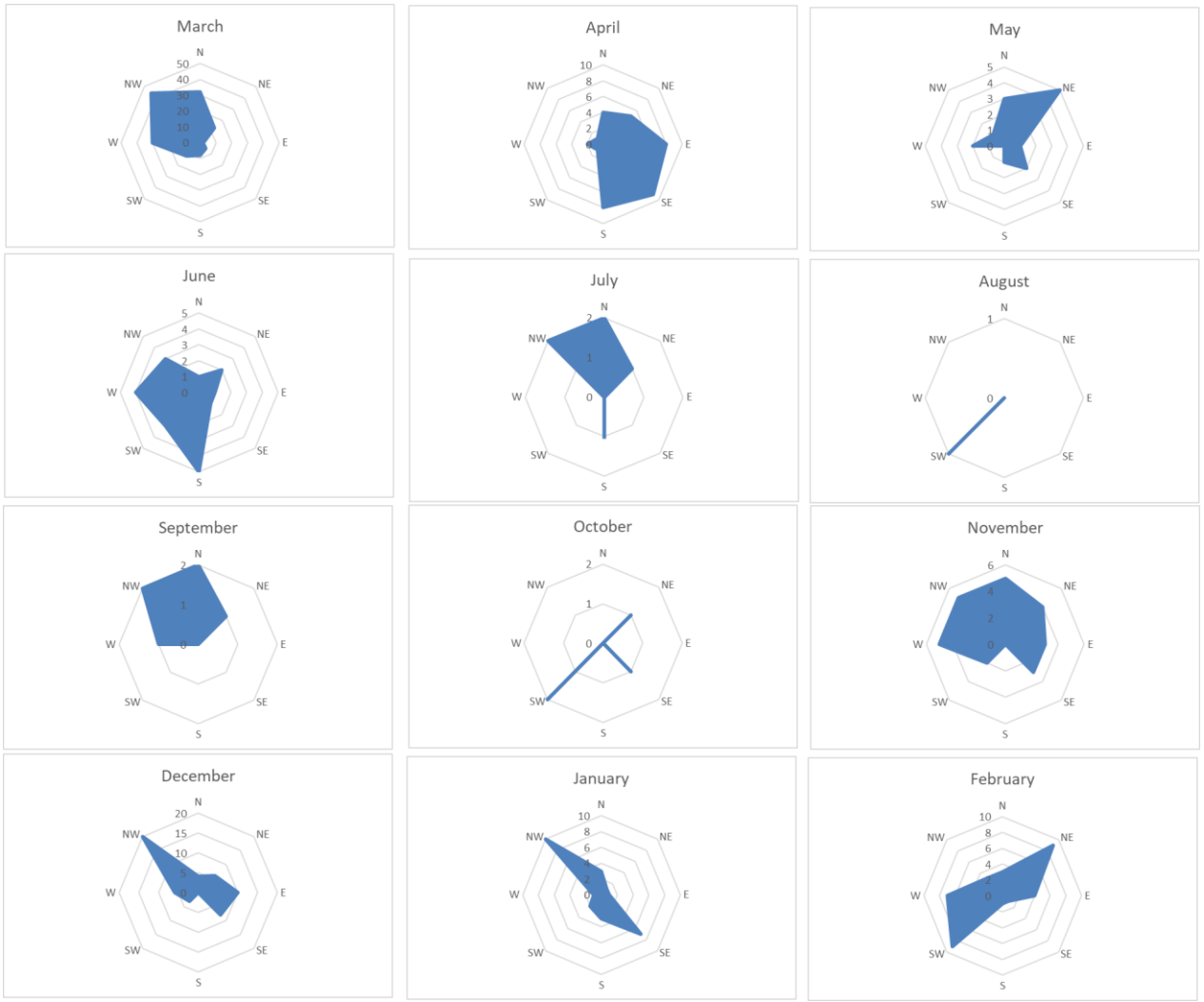
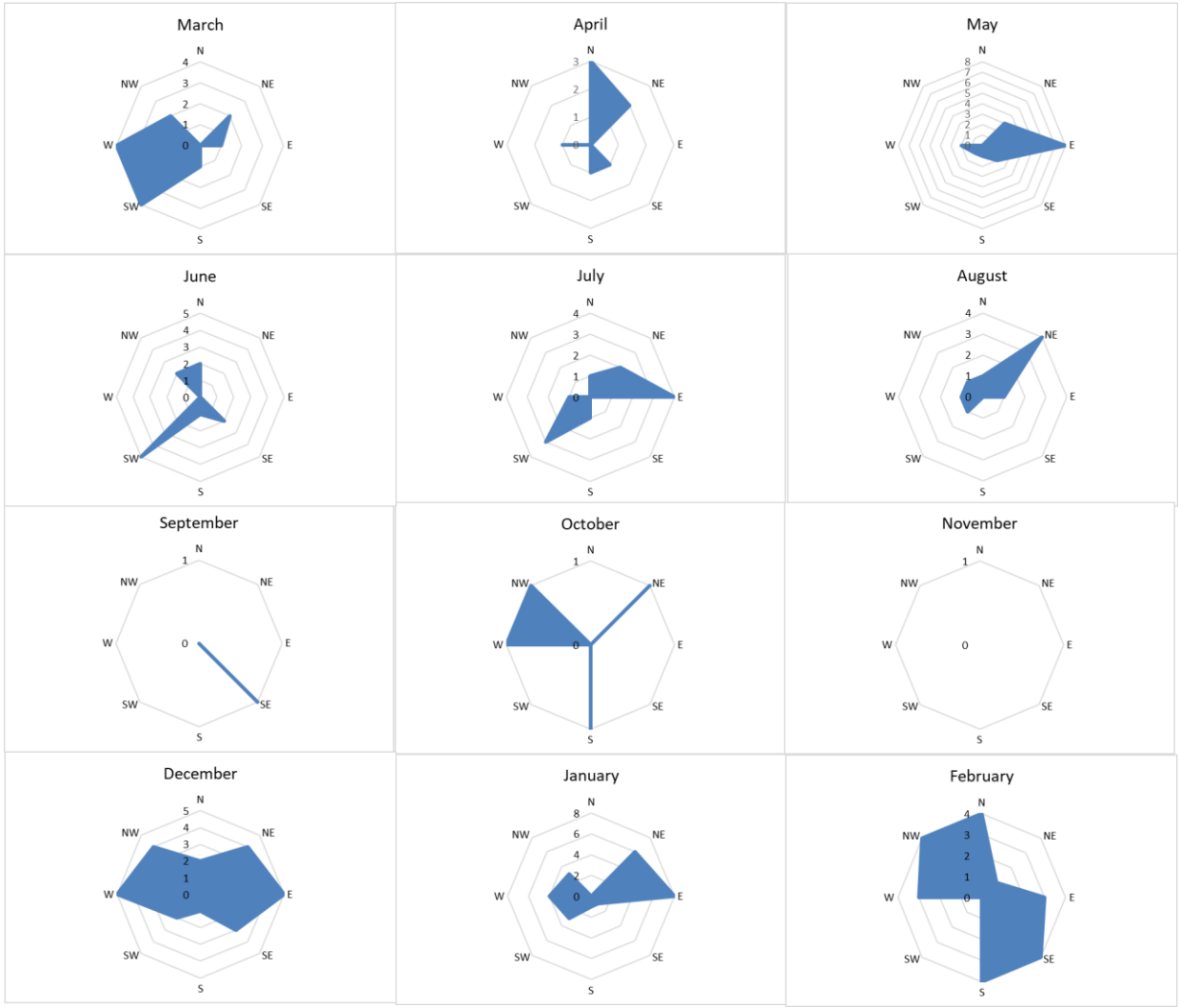


Figure 24 **Flying direction of kittiwakes observed between March 2020 and February 2021**



3.3.5 Lesser black-backed gull

79 Lesser black-backed gulls were recorded in the breeding season, with very few birds present in the winter (Table 21; Figure 25). No birds were recorded in January 2020. Considerably more lesser black-backed gulls were recorded in Year 1 of the study.

80 Density estimates varied (Figure 26), with high densities estimated in June 2019 and July 2020, at 2.64 and 1.73 birds/km^2 respectively. Peak abundances for these months were estimated at 1,601 birds (±95% CI 79 – 4,487) and 1,047 birds (±95% CI 313 – 2,325). Outside of the observed summer peaks, density estimates were much lower in both years, ranging between only 0.01 and 0.56 birds/km^2.

81 In months with low observations, such as in March 2019 and October 2020, no clear distribution pattern could be determined for the species (Figure 27; Figure 28). Lesser black-backed gulls were concentrated in the south of the survey area in several months in 2019, also observed in July and September 2020. July 2019 was the only month in which the north of the study region seemed to be preferred by the species, although some birds were still present in the south east. Distribution was more widespread in June 2020 and January 2021. Many birds were also recorded in the west buffer which overlaps with the operational Galloper Wind Farm.

82 Throughout the two years of data collection, 79% of lesser black-backed gulls that could be aged were recorded as adults, with immature and juvenile birds making up only 19% and 2% of aged birds on average respectively. As expected, these proportions varied between months, such as in June 2019 when 39 immature birds were recorded (Table 22).

83 On average, 43% of birds were recorded flying throughout the survey period (Table 23). Flying rates increased in certain months, such as June 2019 peak, when 74% of birds were exhibiting this behaviour. A large proportion of birds were also recorded as sitting on the water throughout the 24 month period (57%). For several months patterns in flight direction could not be accurately determined (Figure 29; Figure 30). Many birds were recorded flying south-west in June and July 2019 and April 2020. In June 2020 lesser black-backed gulls were primarily recorded moving south-east.

Table 21 Number of lesser black-backed gulls recorded between March 2019 and February 2021

Survey	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Year 1 Total
Lesser black-backed gull	1	30	4	239	152	92	21	1	3	4	0	1	548
Survey	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Year 2 Total**
Lesser black-backed gull	1	13	7	154	18	4	50	2	3	5	5	3	265

Figure 25 **Number of lesser black-backed gulls recorded between March 2019 and February 2021**

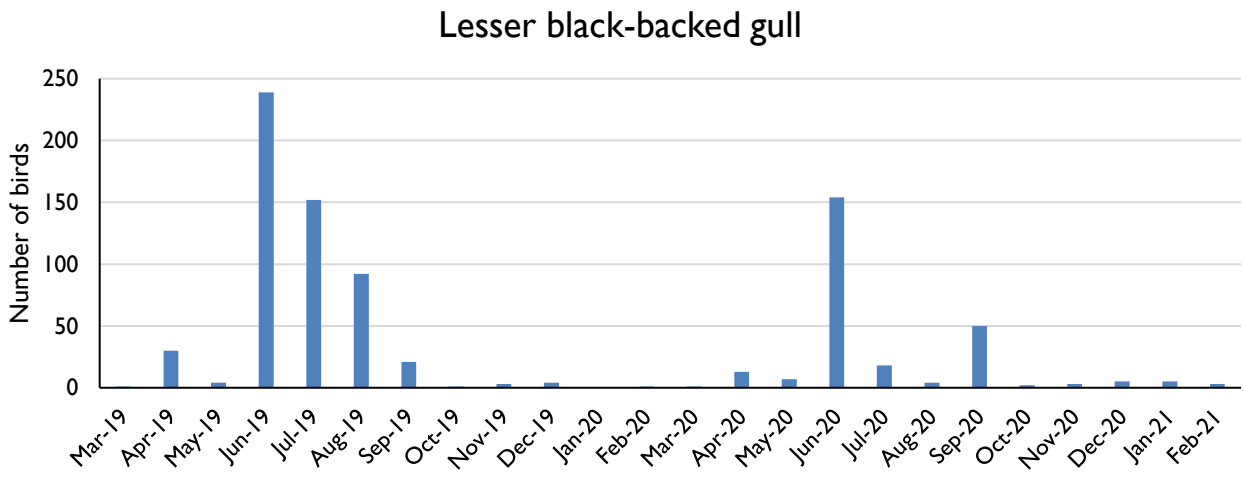


Figure 26 **Lesser black-backed gull density estimates with lower and upper 95% confidence intervals between March 2019 and February 2021**

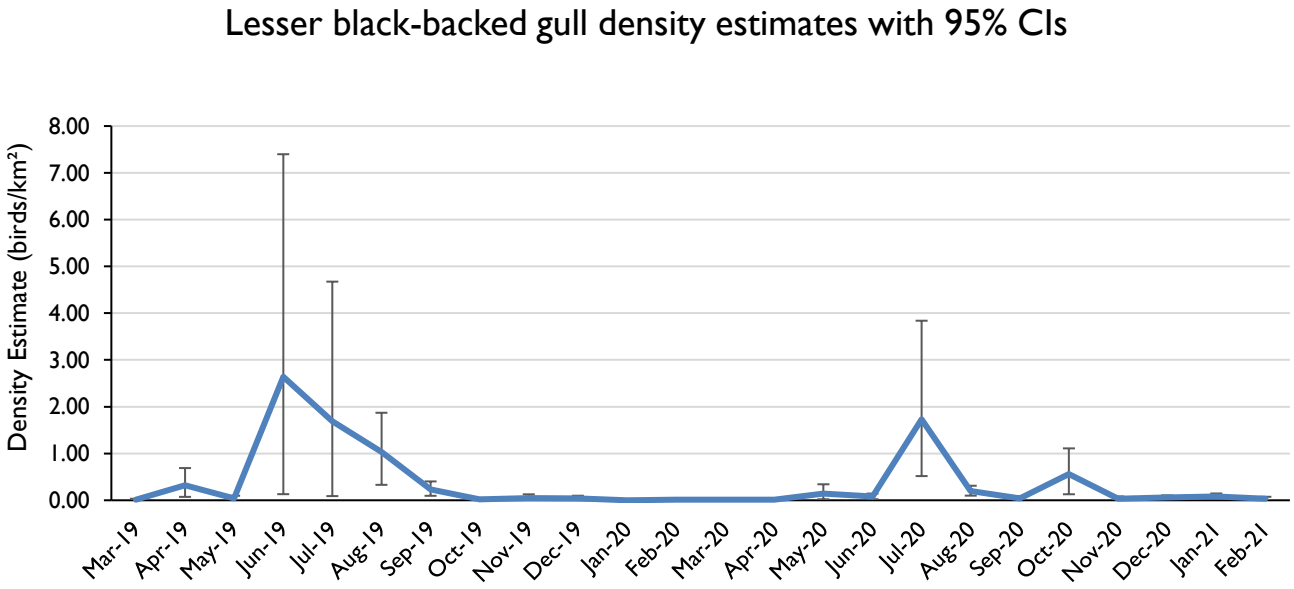


Figure 27 **Density of lesser black-backed gulls (number/km²) and number of detections per segment between March 2019 and February 2020**

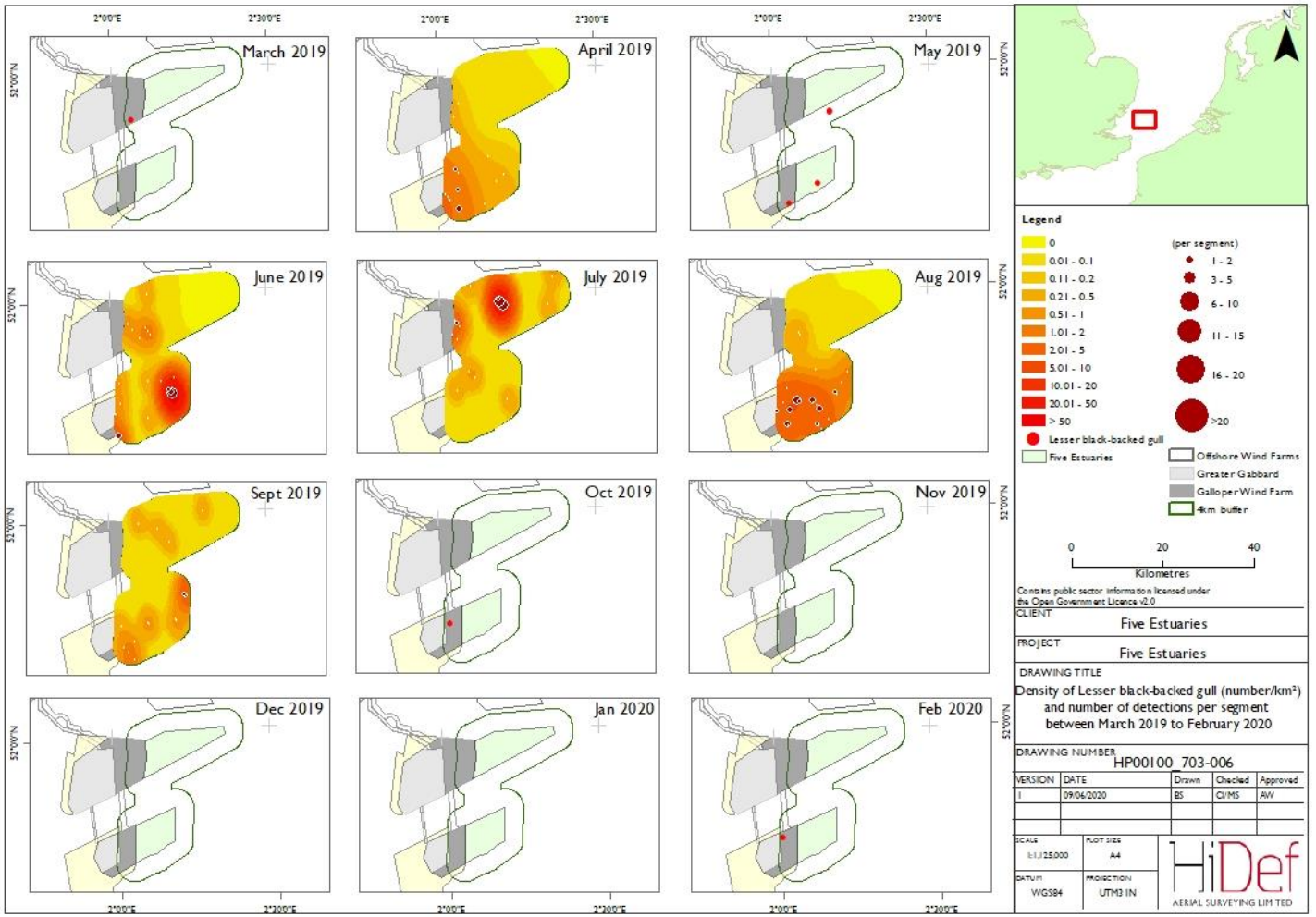


Figure 28 **Density of lesser black-backed gulls (number/km²) and number of detections per segment between March 2020 and February 2021**

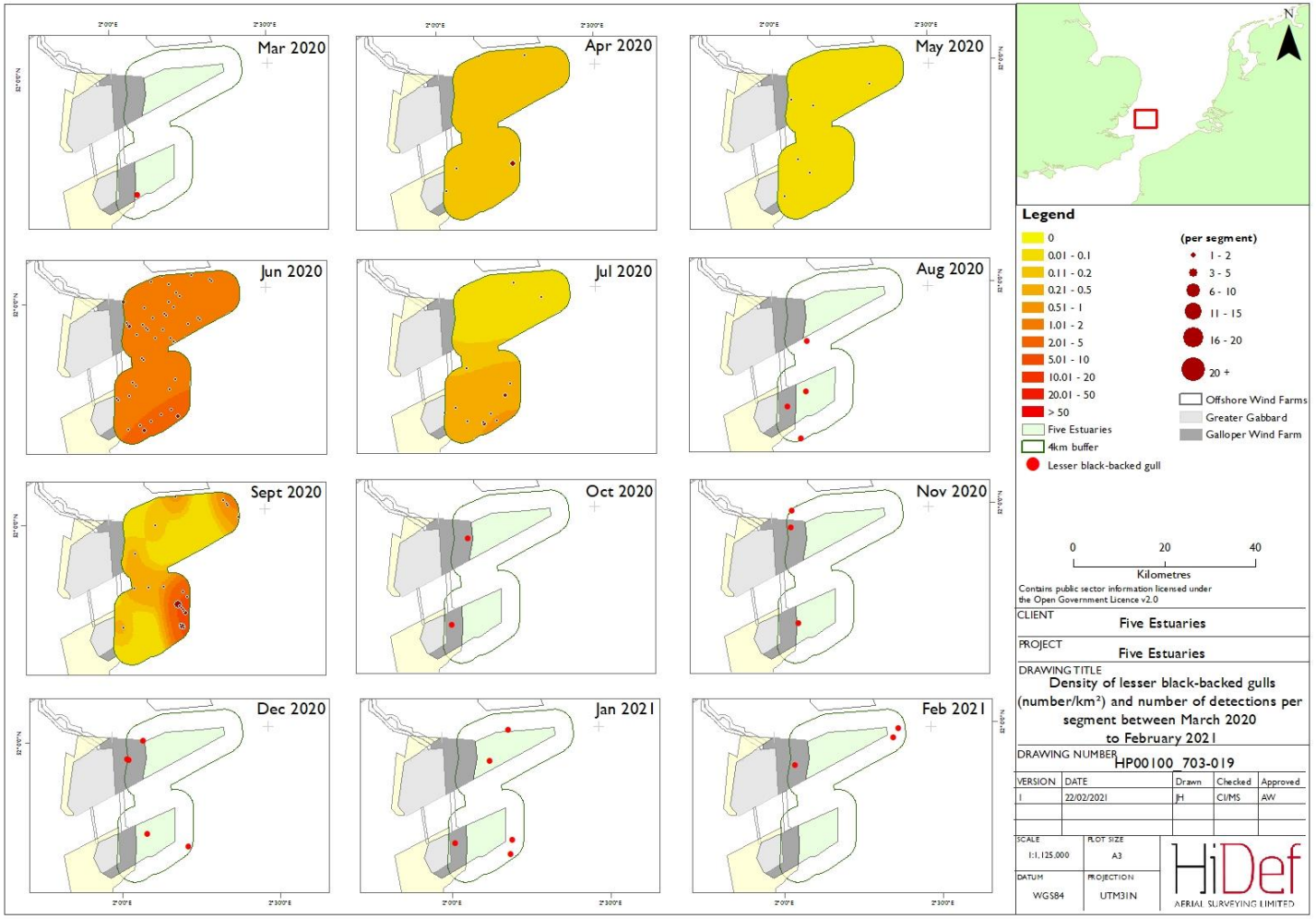


Table 22 Summary of lesser black-backed gull ages between March 2019 and February 2021

Lesser black-backed gull	Number recorded as adult	Number recorded as immature	Number recorded as juvenile	Number recorded as unknown	% Adults (from aged birds)	Total
Mar-19	0	0	0	1	-	1
Apr-19	6	0	0	24	100%	30
May-19	1	0	0	3	100%	4
Jun-19	136	39	0	64	78%	239
Jul-19	31	5	0	116	86%	152
Aug-19	10	0	0	82	100%	92
Sep-19	6	2	5	8	46%	21
Oct-19	0	1	0	0	0%	1
Nov-19	0	1	0	2	0%	3
Dec-19	3	0	0	1	100%	4
Jan-20	0	0	0	0	-	0
Feb-20	0	0	0	1	-	1
Mar-20	1	0	0	0	100%	1
Apr-20	1	6	0	6	14%	13
May-20	2	0	0	5	100%	7
Jun-20	43	4	0	107	91%	154
Jul-20	11	0	0	7	100%	18
Aug-20	1	0	0	3	100%	4
Sep-20	4	3	0	43	57%	50
Oct-20	0	0	0	2	-	2
Nov-20	2	1	0	0	67%	3
Dec-20	5	0	0	0	100%	5
Jan-21	2	0	0	3	100%	5
Feb-21	2	0	0	1	100%	3
Total	**267**	**62**	**5**	**479**	**80%**	**813**

Table 23 Summary of lesser black-backed gull behaviours between March 2019 and February 2021

Survey date	Number recorded diving	Number recorded flying	Number recorded landing	Number recorded sitting	Number recorded taking off	% Flying	Total
Mar-19	0	1	0	0	0	100%	1
Apr-19	0	7	0	23	0	23%	30
May-19	0	1	0	3	0	25%	4
Jun-19	0	176	0	63	0	74%	239
Jul-19	0	38	0	114	0	25%	152
Aug-19	0	10	0	82	0	11%	92
Sep-19	0	13	0	8	0	62%	21
Oct-19	0	1	0	0	0	100%	1
Nov-19	0	1	0	2	0	33%	3
Dec-19	0	4	0	0	0	100%	4
Jan-20	0	0	0	0	0	0%	0
Feb-20	0	0	0	1	0	0%	1
Mar-20	0	1	0	0	0	100%	1
Apr-20	0	10	0	3	0	77%	13
May-20	0	2	0	4	1	29%	7
Jun-20	0	48	0	106	0	31%	154
Jul-20	0	11	0	7	0	61%	18
Aug-20	0	2	0	2	0	50%	4
Sep-20	0	7	0	43	0	14%	50
Oct-20	0	1	0	1	0	50%	2
Nov-20	0	3	0	0	0	100%	3
Dec-20	0	5	0	0	0	100%	5
Jan-21	0	2	0	3	0	40%	5
Feb-21	0	3	0	0	0	100%	3
Total	**0**	**347**	**0**	**465**	**1**	**43%**	**813**

Figure 29 **Flying direction of lesser black-backed gulls observed between March 2019 and February 2020**

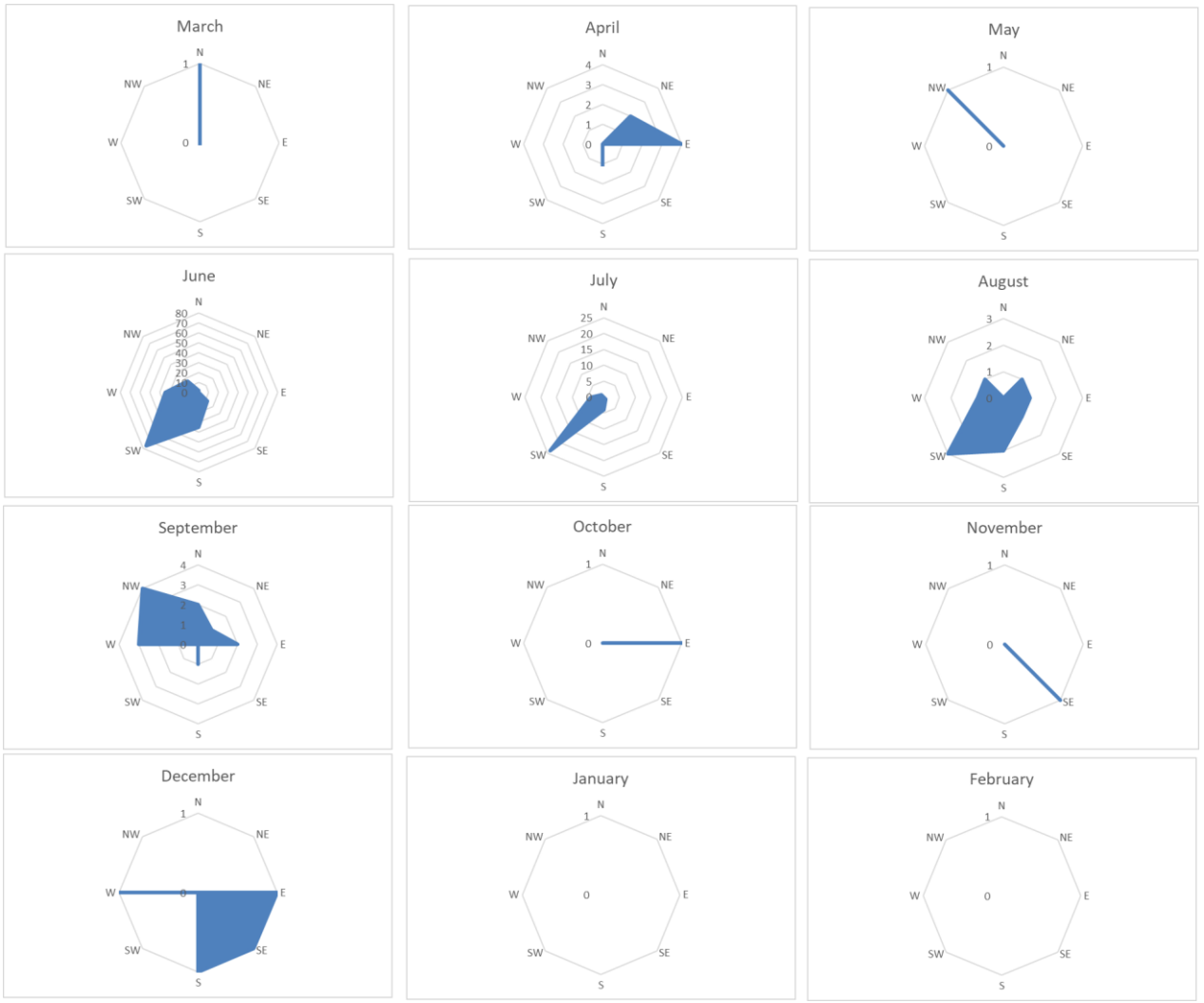
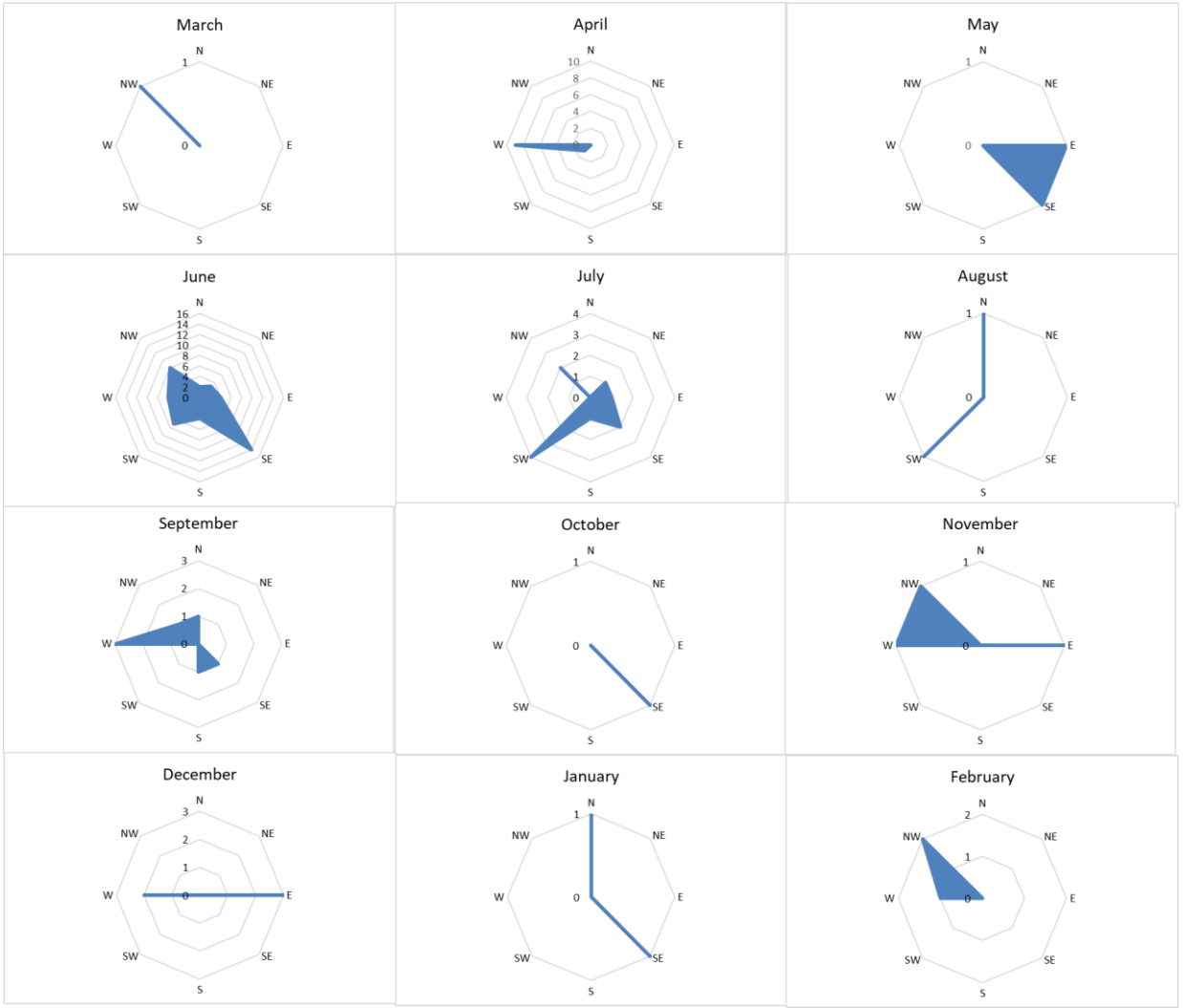


Figure 30 **Flying direction of lesser black-backed gulls observed between March 2020 and February 2021**



3.3.6 Great black-backed gull

84 Great black-backed gulls were recorded in varying numbers throughout the two-year period, peaking in late autumn and winter in both years (Table 24; Figure 31). In both 2019 and 2020, observations were considerably lower in the summer. Similar numbers of birds were recorded in Year 1 and Year 2.

85 Densities of greater black-backed gulls fluctuated throughout the study period, with low densities estimated between March and August in both years, ranging between 0 birds/km^2 between April and August 2020 to 0.07 birds/km^2 in April 2019 (Figure 32). Peak abundances were estimated at 216 birds (±95% CI 54 – 454) in September 2019 and 317 birds (±95% CI 70 – 669) in December 2020.

86 In many months, observations were too few to allow inference of great black-backed gull distributions throughout the survey region (Figure 33; Figure 34). For those where distributions could be assessed, preference to the south-east and west of the study area was observed, such as in September 2019 and December 2020 respectively. In multiple months, greater black-backed gulls were observed in the buffer zone in the west, which overlaps the operational Galloper Wind Farm.

87 Of the birds that could be aged, the majority (61%) were recorded as adults, with only 3 juveniles recorded throughout the entire two-year period, equating to 7% of all aged birds (Table 25). On average, only 26% of all birds were recorded as flying during the study, with 74% recorded as sitting on the water (Table 26). One bird was recorded taking off, observed in February 2021. Due to the low proportion of birds recorded flying, it was difficult to determine patterns in flight direction (Figure 35; Figure 36). In months where many birds were recorded flying, flight direction varied, such as in April 2020 where birds primarily flew west and June 2020 where many birds were recorded flying south-east.

Table 24 Number of great black-backed gulls recorded between March 2019 and February 2021

Survey	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Year 1 Total
Great black-backed gull	3	6	0	2	0	4	32	9	6	4	4	1	71
Survey	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Year 2 Total**
Great black-backed gull	1	0	0	0	0	0	5	9	1	47	11	3	77

Figure 31 **Number of great black-backed gulls recorded between March 2019 and February 2021**

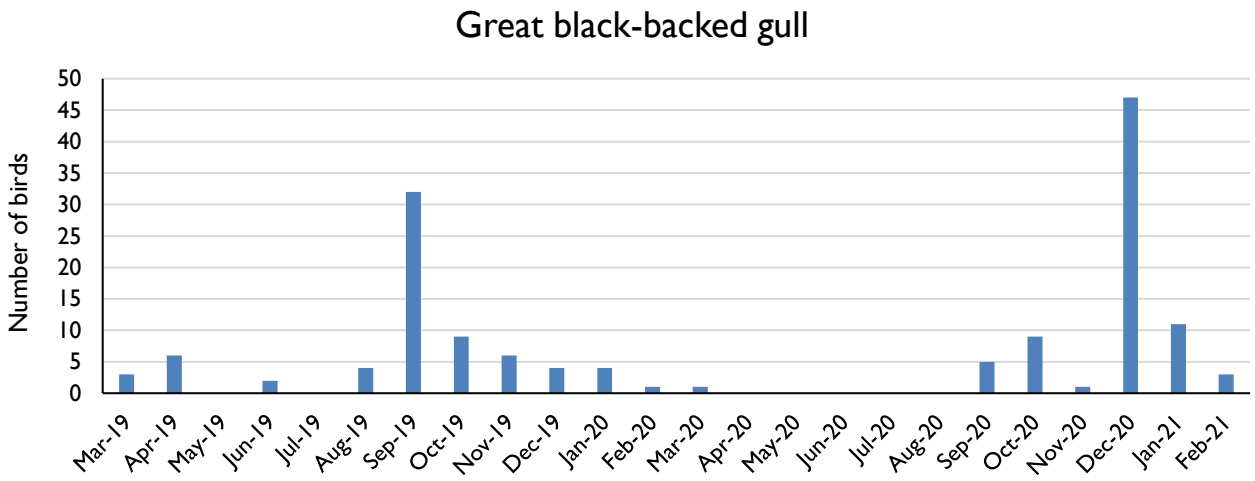


Figure 32 **Great black-backed gull density estimates with lower and upper 95% confidence intervals between March 2019 and February 2021**

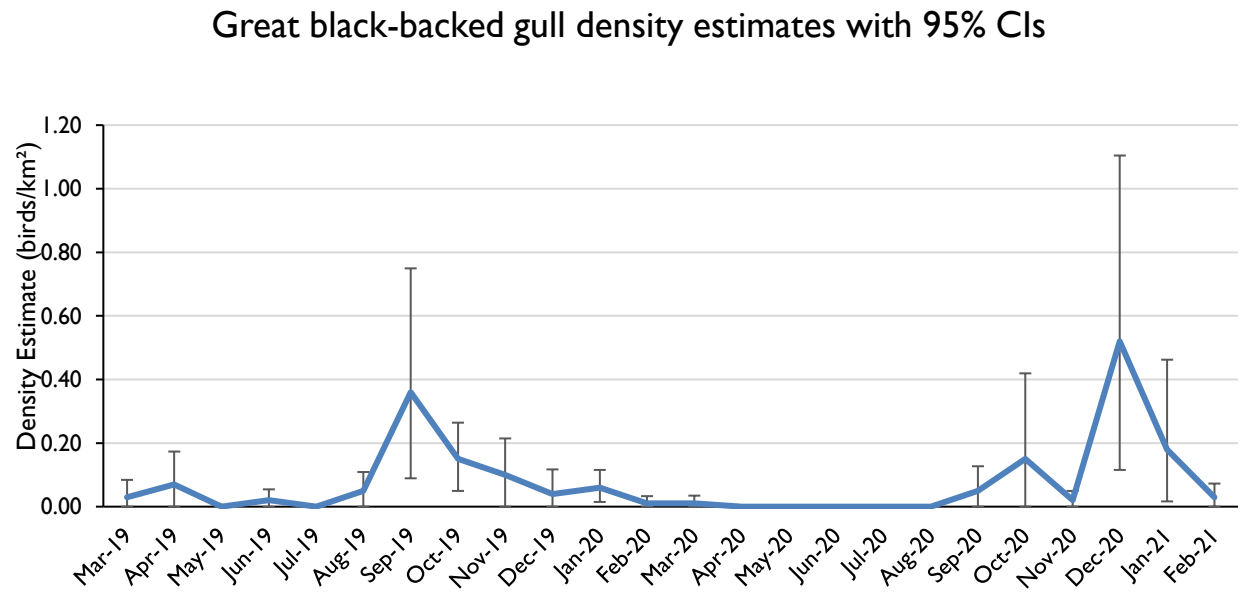


Figure 33 **Density of great black-backed gulls (number/km²) and number of detections per segment between March 2019 and February 2020**

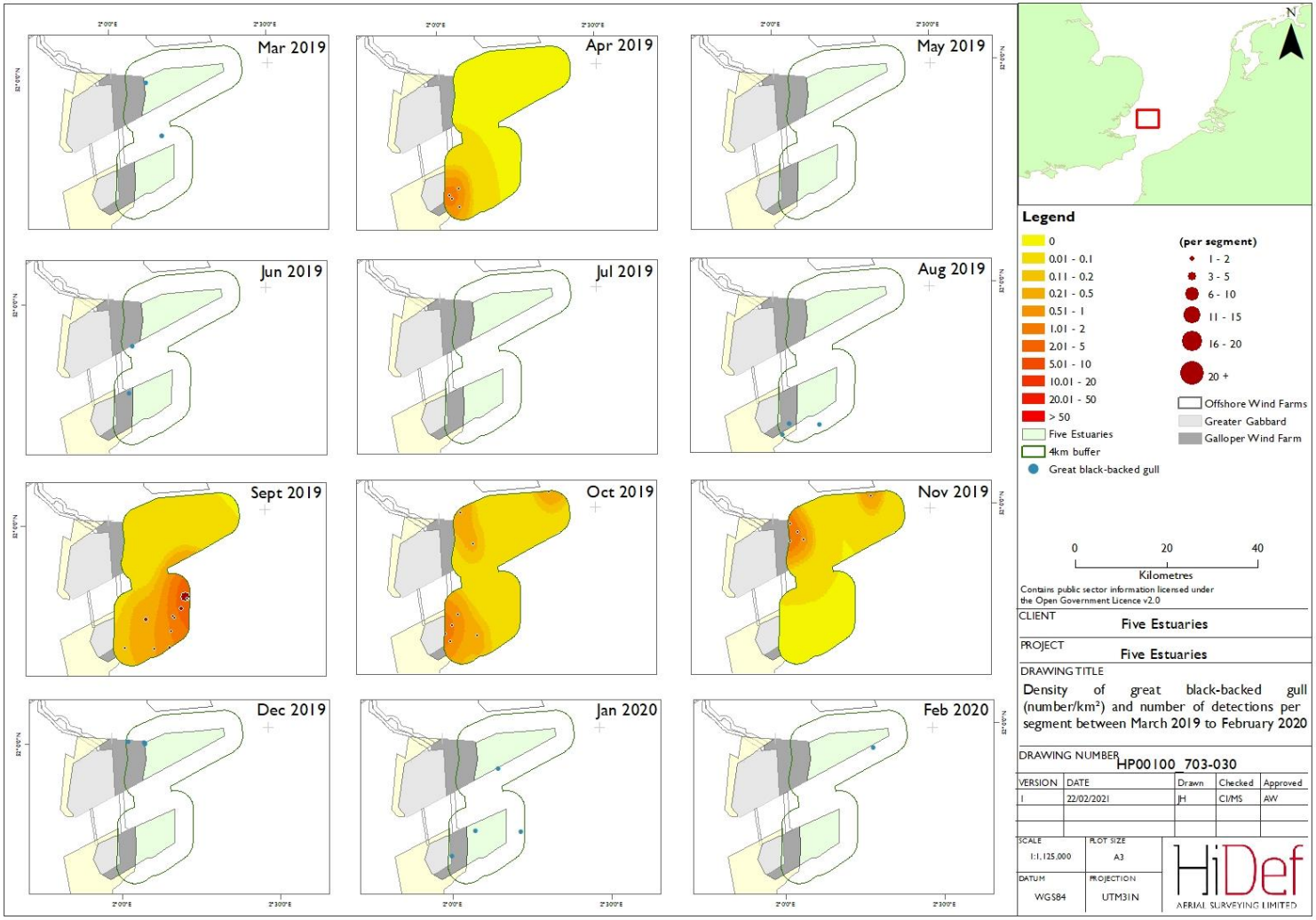


Figure 34 **Density of great black-backed gulls (number/km²) and number of detections per segment between March 2020 and February 2021**

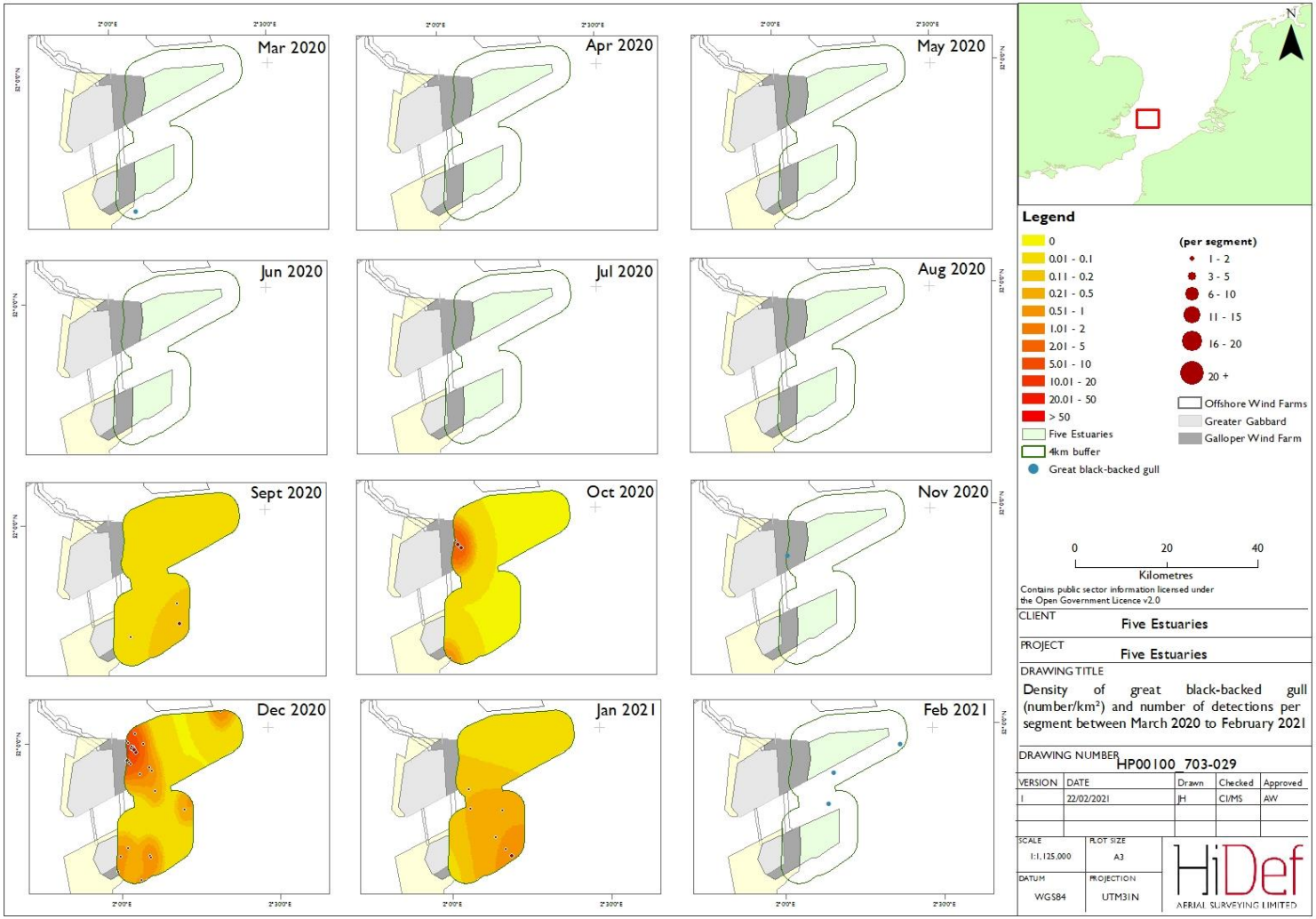


Table 25 Summary of great black-backed gull ages between March 2019 and February 2021

Great black-backed gull	Number recorded as adult	Number recorded as immature	Number recorded as juvenile	Number recorded as unknown	% Adults (from aged birds)	Total
Mar-19	1	0	0	2	100%	3
Apr-19	0	1	0	5	0%	6
May-19	0	0	0	0	-	0
Jun-19	0	2	0	0	0%	2
Jul-19	0	0	0	0	-	0
Aug-19	0	0	0	4	-	4
Sep-19	6	1	2	23	67%	32
Oct-19	3	2	1	3	50%	9
Nov-19	4	2	0	0	67%	6
Dec-19	0	0	0	4	-	4
Jan-20	1	1	0	2	50%	4
Feb-20	0	1	0	0	0%	1
Mar-20	0	0	0	1	-	1
Apr-20	0	0	0	0	-	0
May-20	0	0	0	0	-	0
Jun-20	0	0	0	0	-	0
Jul-20	0	0	0	0	-	0
Aug-20	0	0	0	0	-	0
Sep-20	1	0	0	4	100%	5
Oct-20	1	0	0	8	100%	9
Nov-20	0	0	0	1	-	1
Dec-20	5	3	0	39	63%	47
Jan-21	2	0	0	9	100%	11
Feb-21	1	0	0	2	100%	3
Total	**25**	**13**	**3**	**107**	**61%**	**148**

Table 26 Summary of great black-backed gull behaviours between March 2019 and February 2021

Survey date	Number recorded diving	Number recorded flying	Number recorded landing	Number recorded sitting	Number recorded taking off	% Flying	Total
Mar-19	0	1	0	2	0	33%	3
Apr-19	0	0	0	6	0	0%	6
May-19	0	0	0	0	0	0%	0
Jun-19	0	2	0	0	0	100%	2
Jul-19	0	0	0	0	0	0%	0
Aug-19	0	0	0	4	0	0%	4
Sep-19	0	9	0	23	0	28%	32
Oct-19	0	4	0	5	0	44%	9
Nov-19	0	5	0	1	0	83%	6
Dec-19	0	0	0	4	0	0%	4
Jan-20	0	2	0	2	0	50%	4
Feb-20	0	1	0	0	0	100%	1
Mar-20	0	0	0	1	0	0%	1
Apr-20	0	0	0	0	0	0%	0
May-20	0	0	0	0	0	0%	0
Jun-20	0	0	0	0	0	0%	0
Jul-20	0	0	0	0	0	0%	0
Aug-20	0	0	0	0	0	0%	0
Sep-20	0	1	0	4	0	20%	5
Oct-20	0	1	0	8	0	11%	9
Nov-20	0	0	0	1	0	0%	1
Dec-20	0	8	0	39	0	17%	47
Jan-21	0	3	0	8	0	27%	11
Feb-21	0	1	0	1	1	33%	3
Total	**0**	**38**	**0**	**109**	**1**	**26%**	**148**

Figure 35 Flying direction of great black-backed gulls observed between March 2019 and February 2020

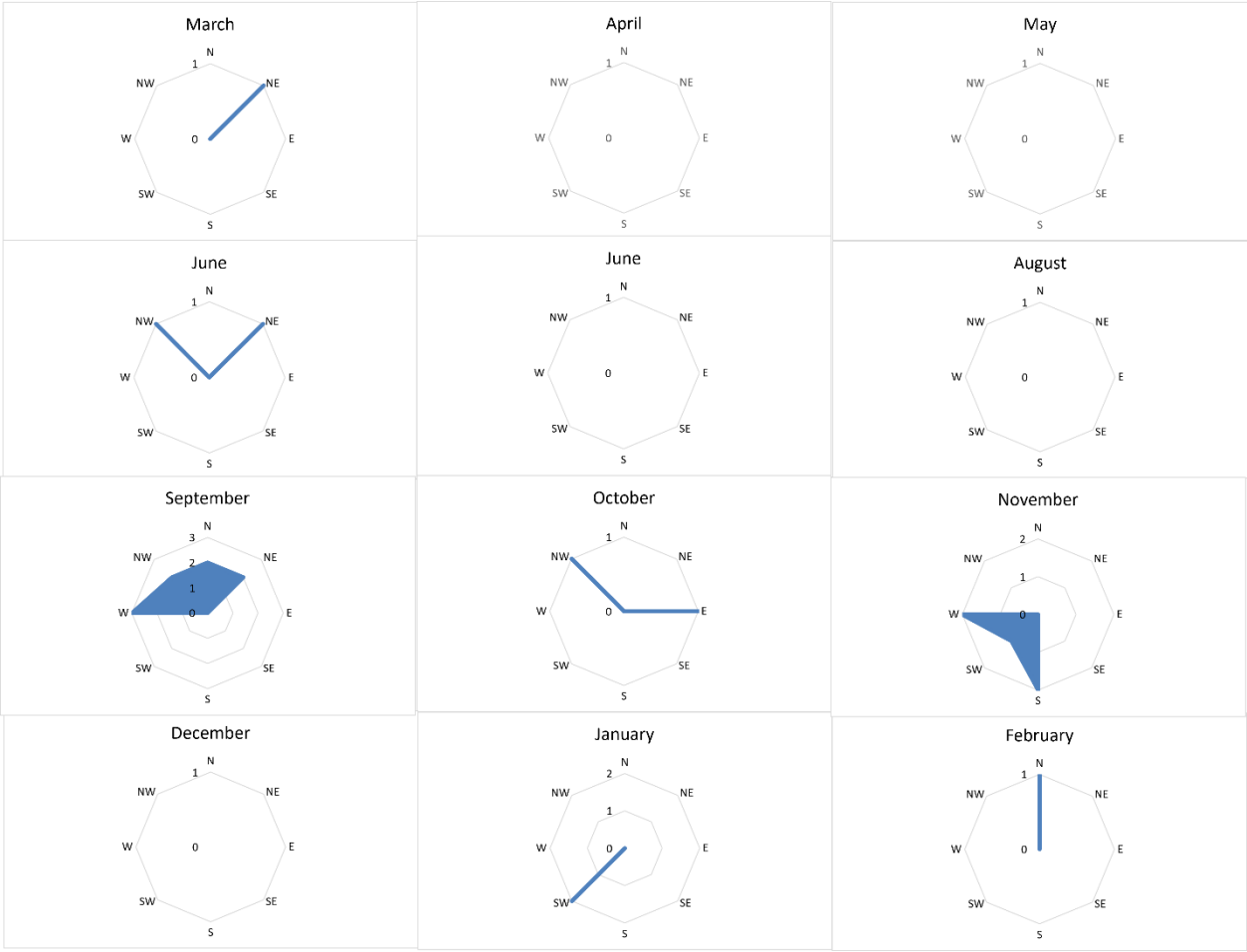
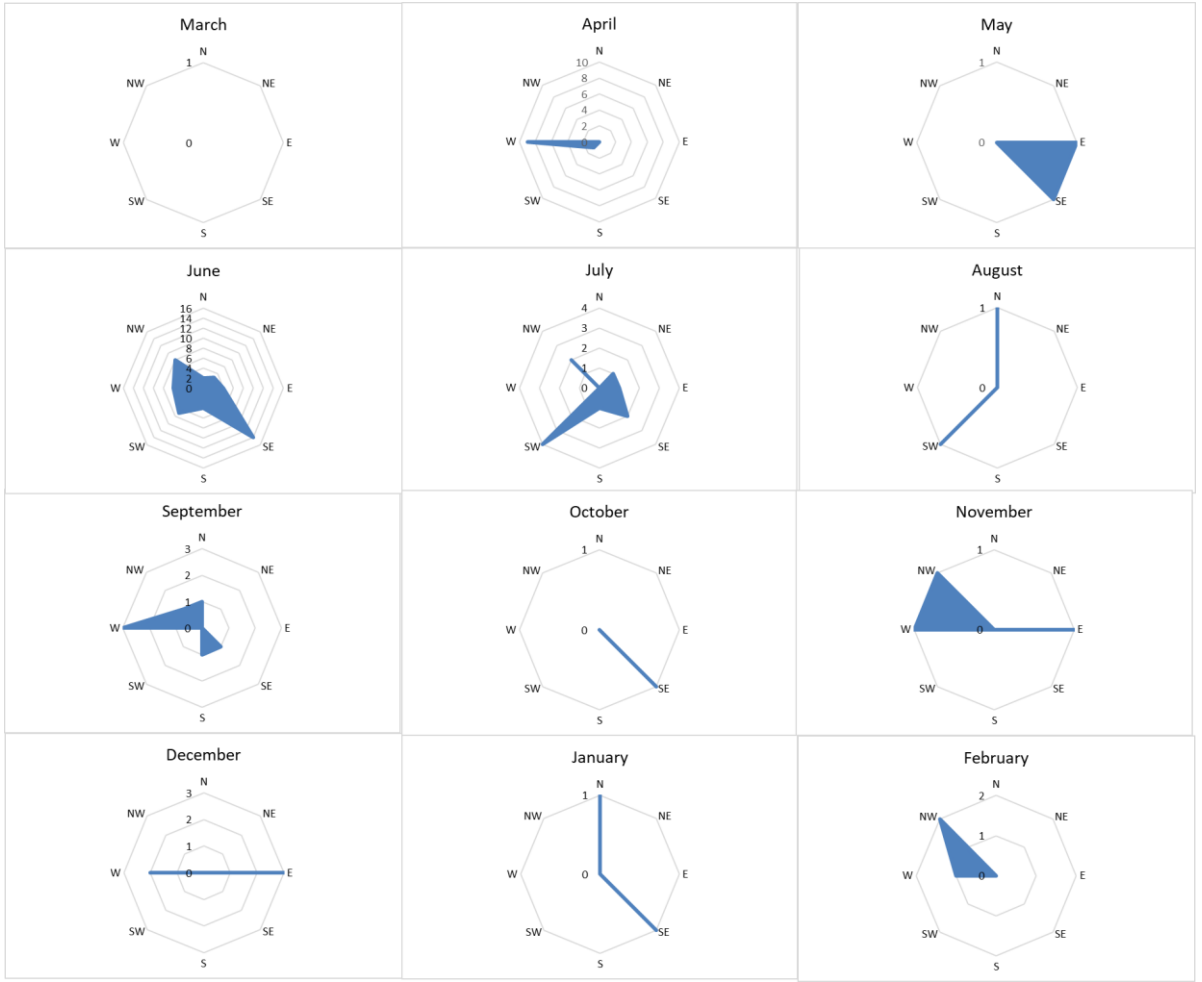


Figure 36 Flying direction of great black-backed gulls observed between March 2020 and February 2021



3.3.7 Guillemot

88 Guillemots were the most abundant species recorded during the survey programme, occurring in high densities in the winter months, with peak observations recorded in February 2020 (Table 27; Figure 37). Over three times as many birds were recorded in Year 1 compared to Year 2. Low numbers of the species were recorded from May to October 2019 and between July and August 2020.

89 Absolute density and abundance estimates varied markedly (Figure 38). A secondary peak in abundance in March 2019, placed the guillemot population at 4,516 birds (±95% CI 3,119 – 6,109). Very low densities were estimated between May and October 2019, ranging between 0 and 0.56 birds/km^2, equating to an absolute abundance of no more than 335 birds (±95% CI 178 - 491). Numbers increased again over the winter, with peak density occurring in February, at 13.32 birds/km^2, equating to an estimated absolute abundance of 11,283 birds (±95% CI 8066 – 14,637). Abundance dropped markedly in the 2020 breeding season, before reaching a 2020/21 winter peak of 2.46 birds/km^2 in December 2020; equating to 1,493 birds (±95% CI 1,092 – 1,938).

90 Guillemots were widely dispersed across the study area in the spring and winter months in both years, with particularly high densities in the north in March 2019 and the south in February 2020 (Figure 39). In both Year 1 and Year 2 the lowest densities were recorded in the north west of the site near existing turbines.

91 As is expected for the species, the majority of birds were recorded sitting on the water (Table 28). Only 2% of birds on average throughout the two years of data collection, were recorded flying. Since many birds were sat on the water, relatively little data regarding flight direction was collected. Despite this, a large proportion of flying birds recorded in January and February 2020 were heading eastwards (Figure 41). The majority of flying birds in January 2021 flew west (Figure 42).

92 No immature birds were recorded across the entire survey programme, with only one juvenile bird recorded in July 2019.

Table 27 Number of guillemots recorded between March 2019 and February 2021

Survey	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Year 1 Total
Guillemot	545	305	11	0	11	12	4	27	109	168	157	1368	2717
Survey	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Year 2 Total**
Guillemot	126	118	58	7	8	1	49	17	20	186	90	120	800

Figure 37 **Number of guillemots recorded between March 2019 and February 2021**

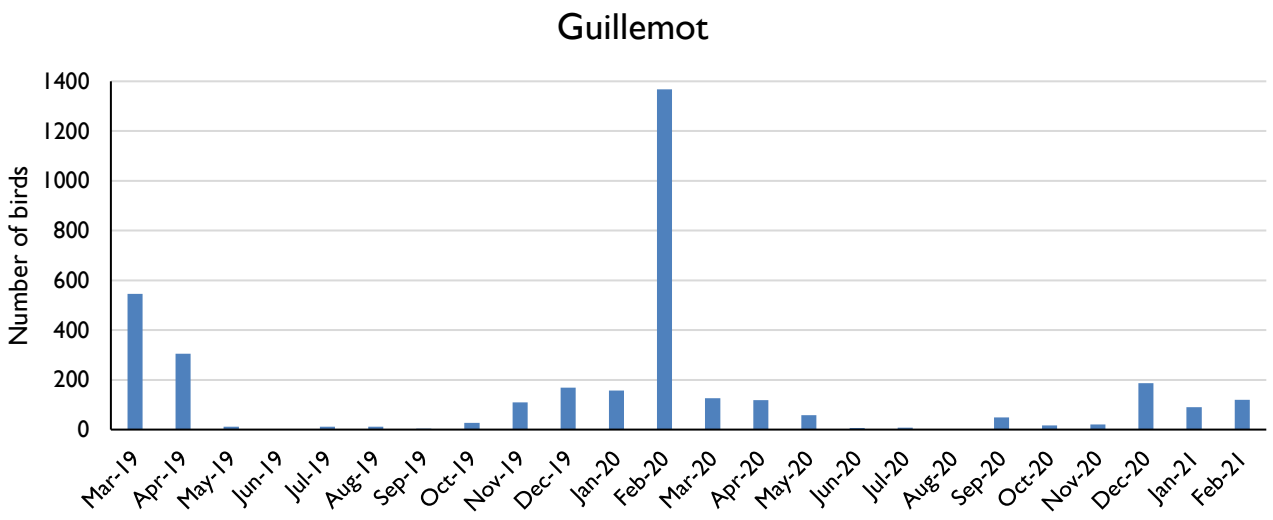


Figure 38 **Guillemot absolute density estimates with lower and upper 95% confidence intervals between March 2019 and February 2021**

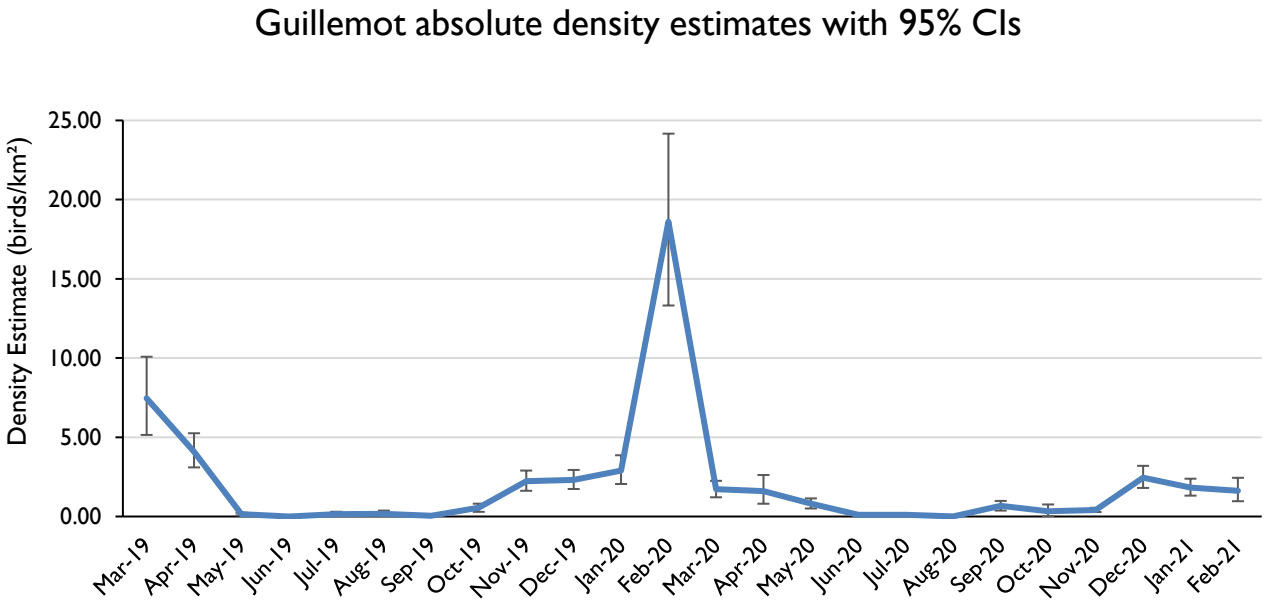


Figure 39 Density of guillemot (number/km²) and number of detections per segment between March 2019 and February 2020

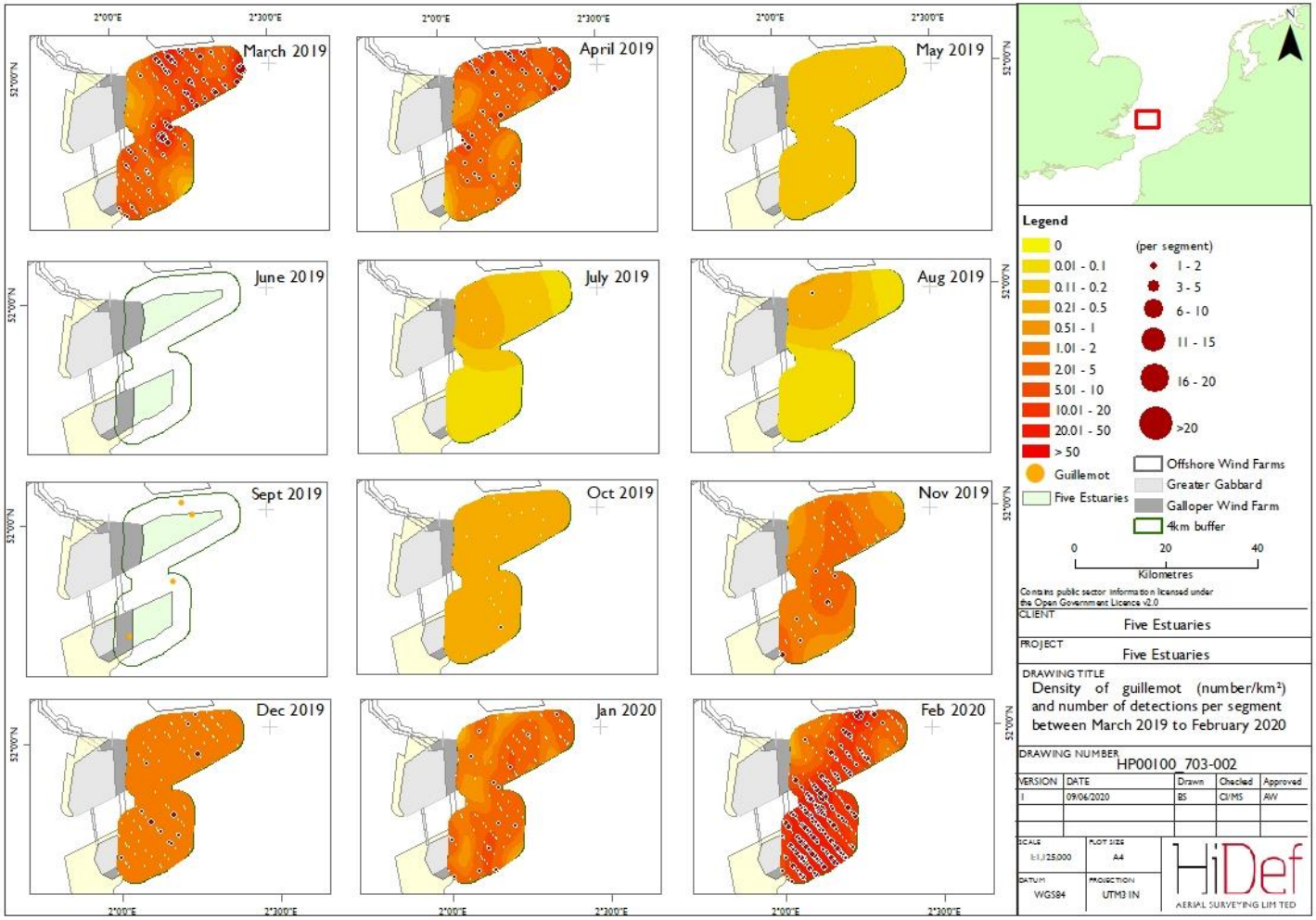


Figure 40 **Density of guillemots (number/km²) and number of detections per segment between March 2020 and February 2021**

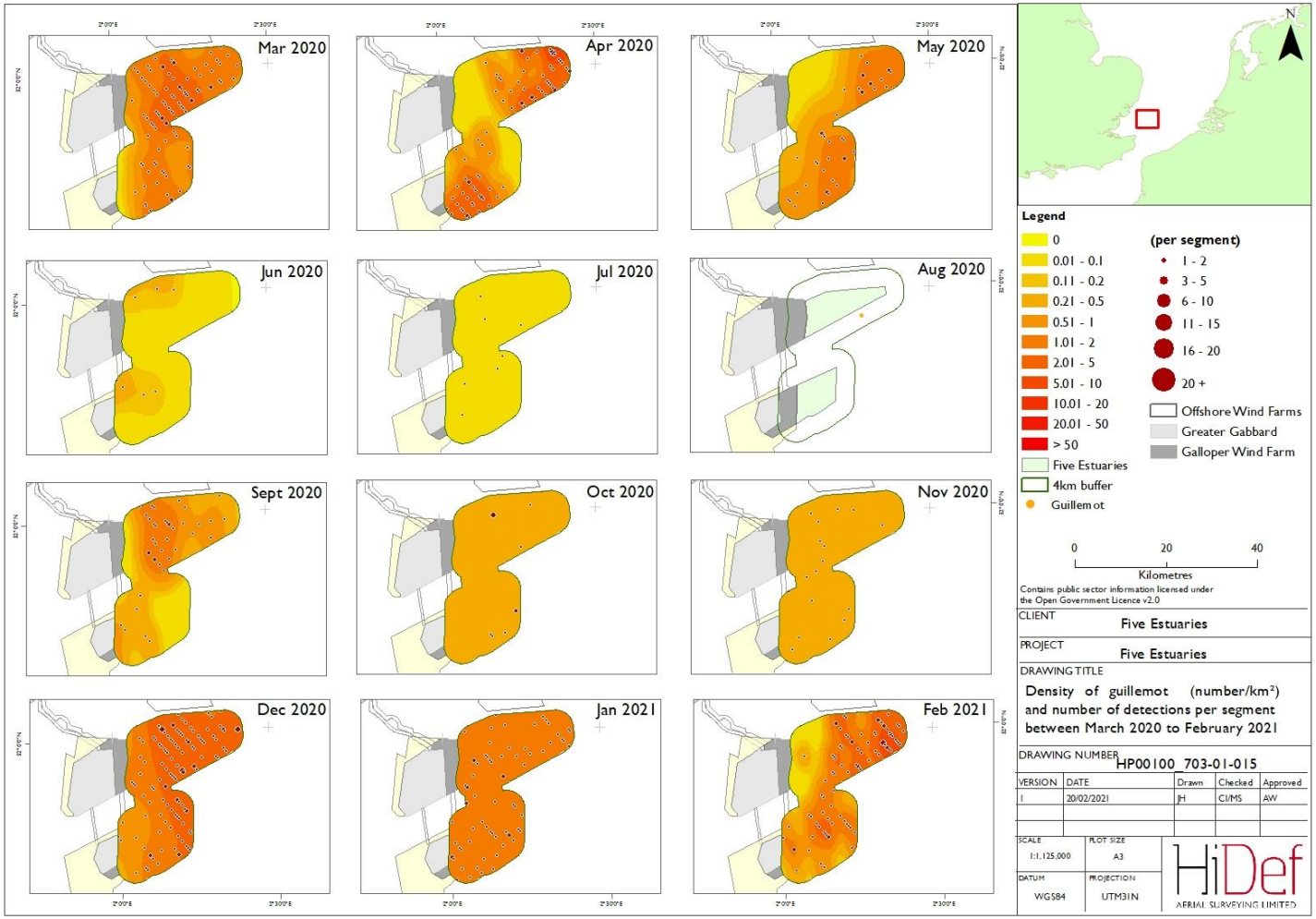


Table 28 Summary of guillemot behaviours between March 2019 and February 2020

Survey date	Number recorded diving	Number recorded flying	Number recorded landing	Number recorded sitting	Number recorded taking off	% Flying	Total
Mar-19	0	5	0	540	0	1%	545
Apr-19	0	1	0	303	1	0%	305
May-19	0	0	0	11	0	0%	11
Jun-19	0	0	0	0	0	0%	0
Jul-19	0	0	0	11	0	0%	11
Aug-19	0	0	0	12	0	0%	12
Sep-19	0	0	0	4	0	0%	4
Oct-19	0	0	0	27	0	0%	27
Nov-19	0	2	0	107	0	2%	109
Dec-19	0	7	0	161	0	4%	168
Jan-20	0	12	0	145	0	8%	157
Feb-20	0	19	0	1349	0	1%	1368
Mar-20	0	0	0	126	0	0%	126
Apr-20	0	4	0	114	0	3%	118
May-20	0	0	0	58	0	0%	58
Jun-20	0	0	0	7	0	0%	7
Jul-20	0	2	0	6	0	25%	8
Aug-20	0	0	0	1	0	0%	1
Sep-20	0	0	0	49	0	0%	49
Oct-20	0	5	0	12	0	29%	17
Nov-20	0	0	0	20	0	0%	20
Dec-20	0	6	0	180	0	17%	186
Jan-21	0	9	0	81	0	10%	90
Feb-21	0	8	0	112	0	7%	120
Total	**0**	**80**	**0**	**3436**	**1**	**2%**	**3517**

Figure 41 Flying direction of guillemots observed between March 2019 and February 2020

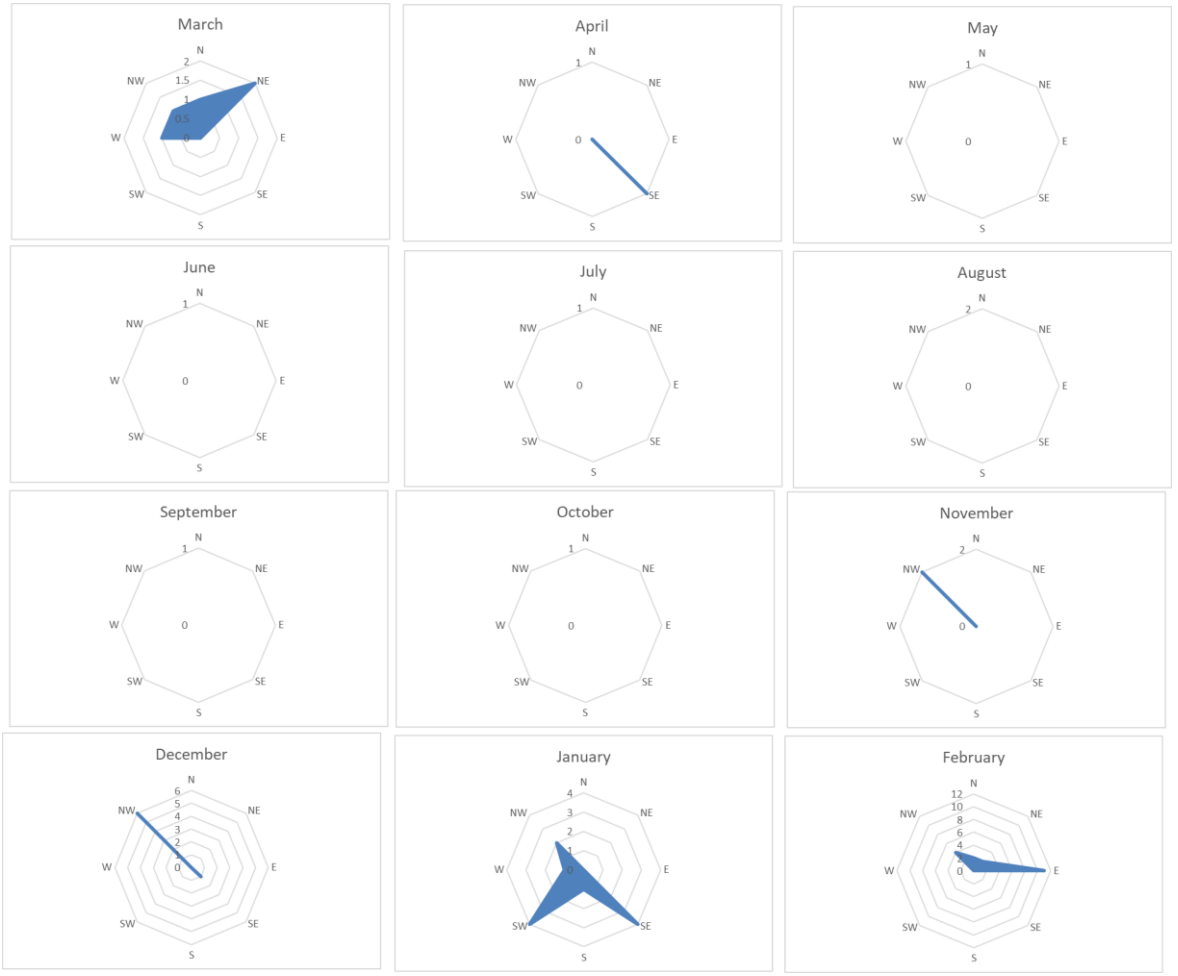
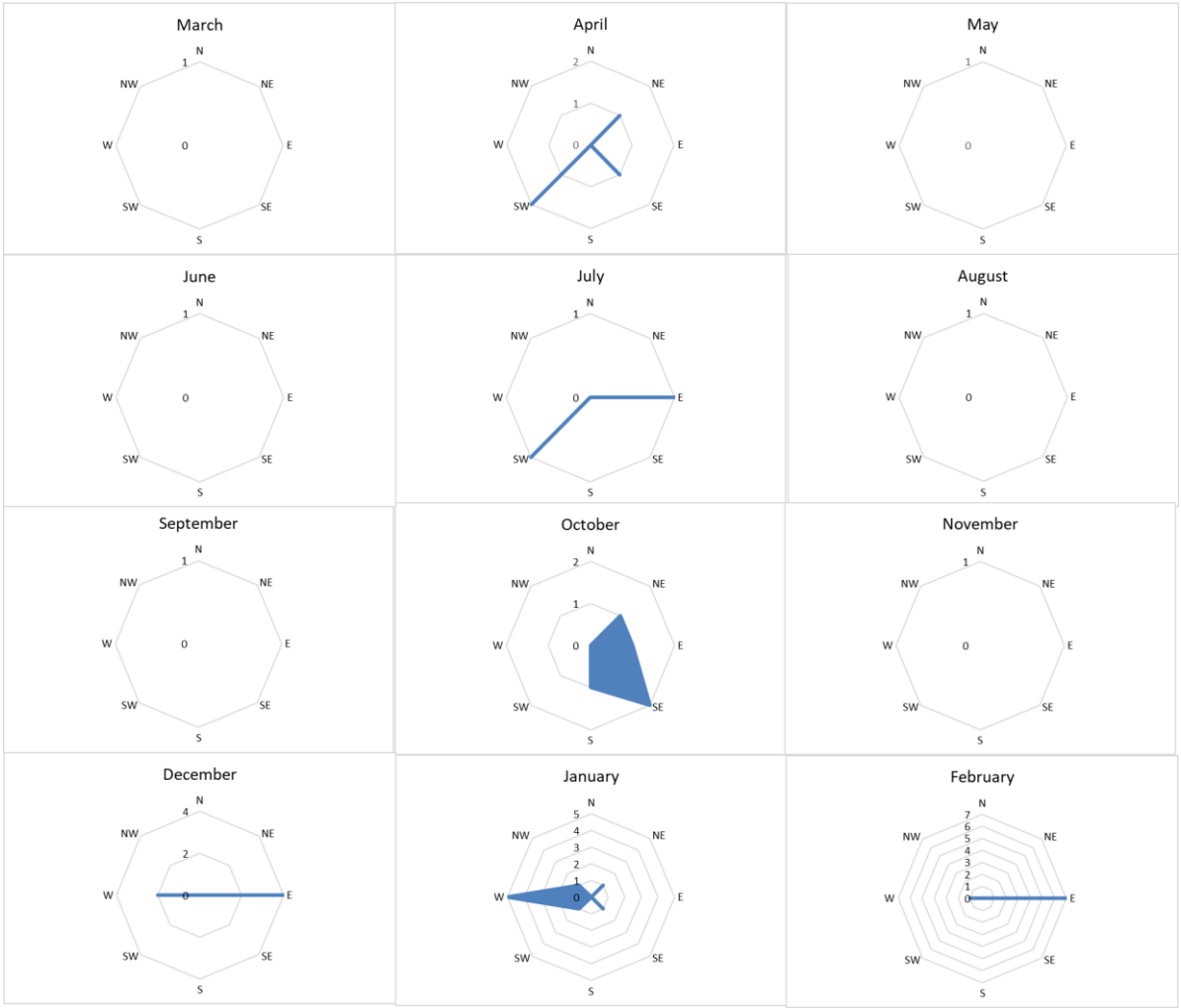


Figure 42 Flying direction of guillemots observed between March 2020 and February 2021



3.3.8 Razorbill

93 Razorbills were the second most abundant species of the survey programme, with peak observations recorded in winter months. Very low numbers were recorded from June to September in both years (Table 29; Figure 43).

94 Absolute density and population estimates varied through the survey period (Figure 44). In March 2019, peak density reached 4.34 birds/km², equating to an estimated 2,633 birds (±95% CI 1,781 – 3,593) in the survey area. Between May and September 2019, densities were low, ranging between 0 and 0.11 birds/km², equating to no more than 62 birds (±95% CI 15 – 119). Between October 2019 and April 2020, moderate to high densities were recorded, ranging between 0.2 and 3.79 birds/km², with an estimated 2,302 birds (±95% CI 1,489 – 3,233) in December 2019. Razorbill numbers dropped markedly again in the summer of 2020, found in similar abundances as the previous year. From October 2020 to February 2021, average density ranged between 0.72 and 2.02 birds/km².

95 The distribution pattern for razorbills varied across the surveys (Figure 45; Figure 46). In October 2019 razorbills were concentrated in the south-east and west of the survey aera, similar to November 2019 where razorbills were also present in the west. In all March and December surveys, razorbills seemed to be concentrated to the north of the survey area, however for the rest of the year distributions were more widespread. This was particularly true for February 2020 and January 2021.

96 As is expected for the species, the majority of razorbills were recorded sitting on the water, with 5% of birds recorded flying across the entire study period (Table 30). Following this, it was difficult to distinguish patterns in flight direction for many months (Figure 47; Figure 48). In February and October 2020, when a relatively high number of flying birds were recorded, 58% of birds were flying in a north-westerly direction.

97 No juvenile or immature birds were identified.

Table 29 Number of razorbills recorded between March 2019 and February 2021

Survey	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Year 1 Total
Razorbill	333	46	8	0	1	2	0	50	41	290	49	230	1050
Survey	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Year 2 Total**
Razorbill	119	16	8	0	0	1	0	40	40	170	38	81	513

Figure 43 **Number of razorbills recorded between March 2019 and February 2021**

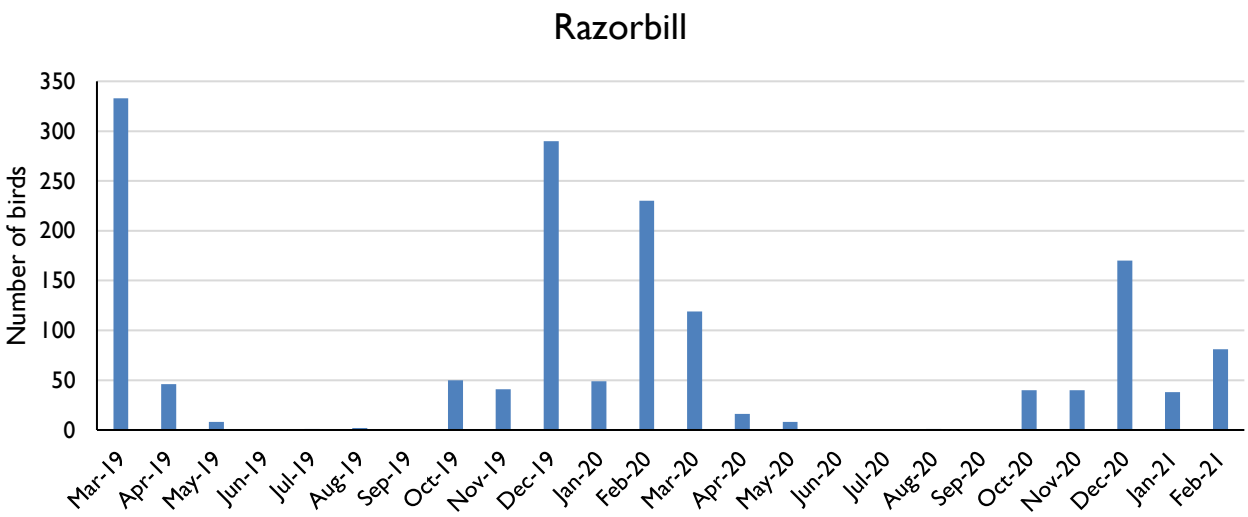


Figure 44 **Razorbill absolute density estimates with lower and upper 95% confidence intervals between March 2019 and February 2021**

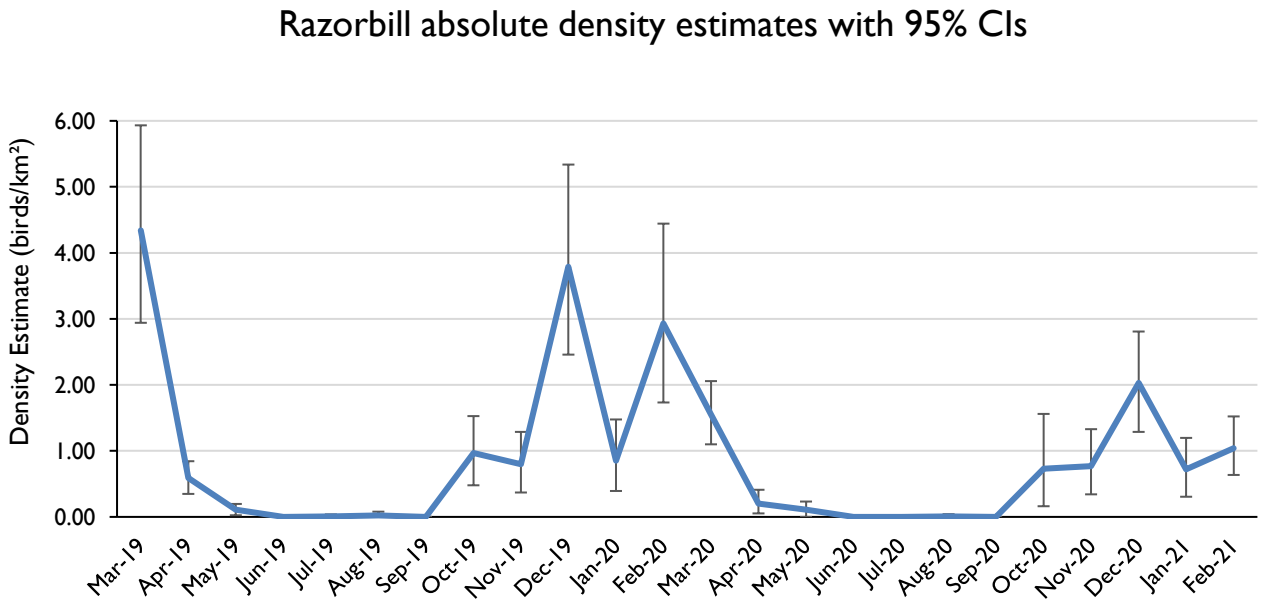


Figure 45 **Density of razorbill (number/km²) and number of detections per segment between March 2019 and February 2020**

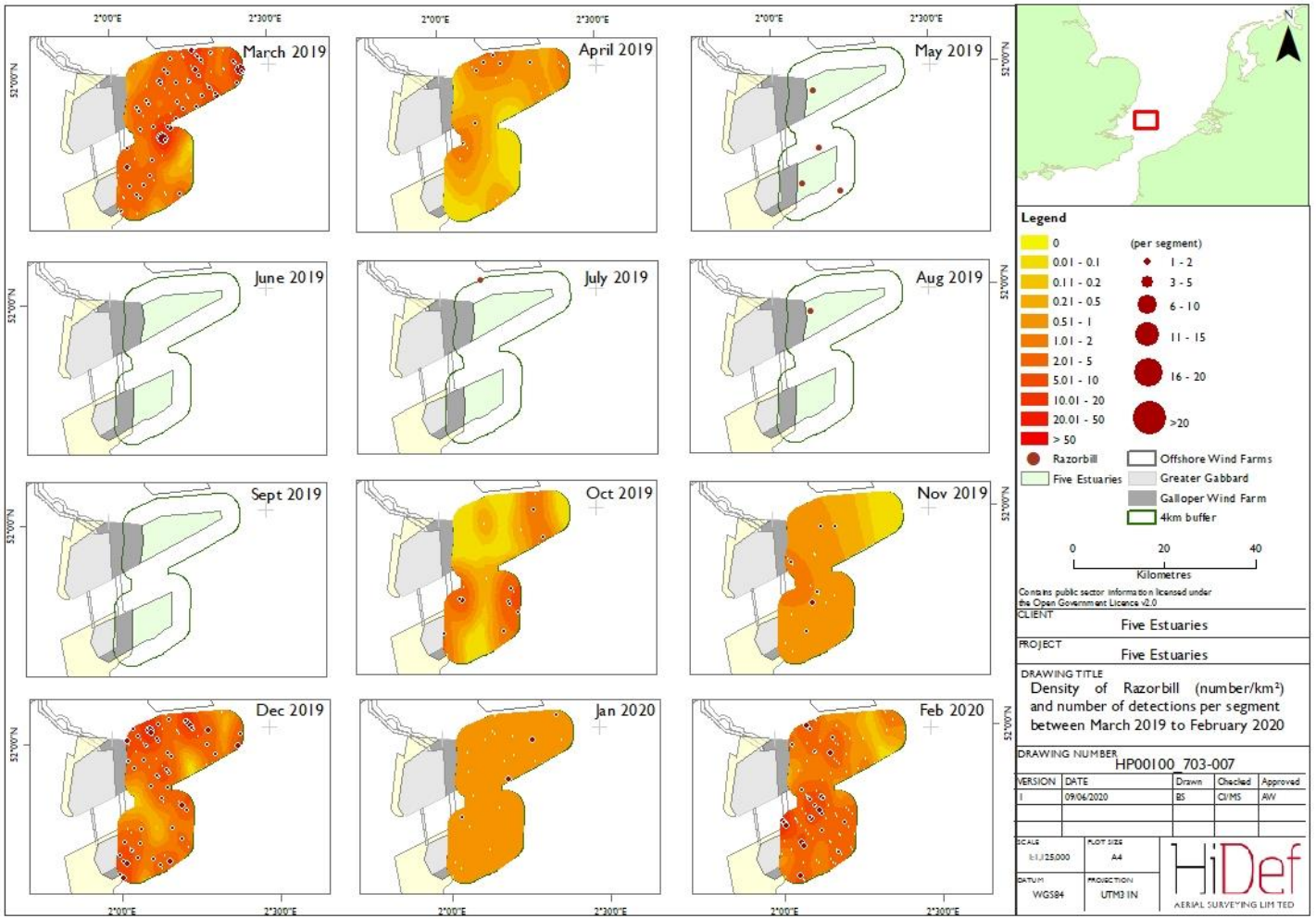


Figure 46 **Density of razorbills (number/km²) and number of detections per segment between March 2020 and February 2021**

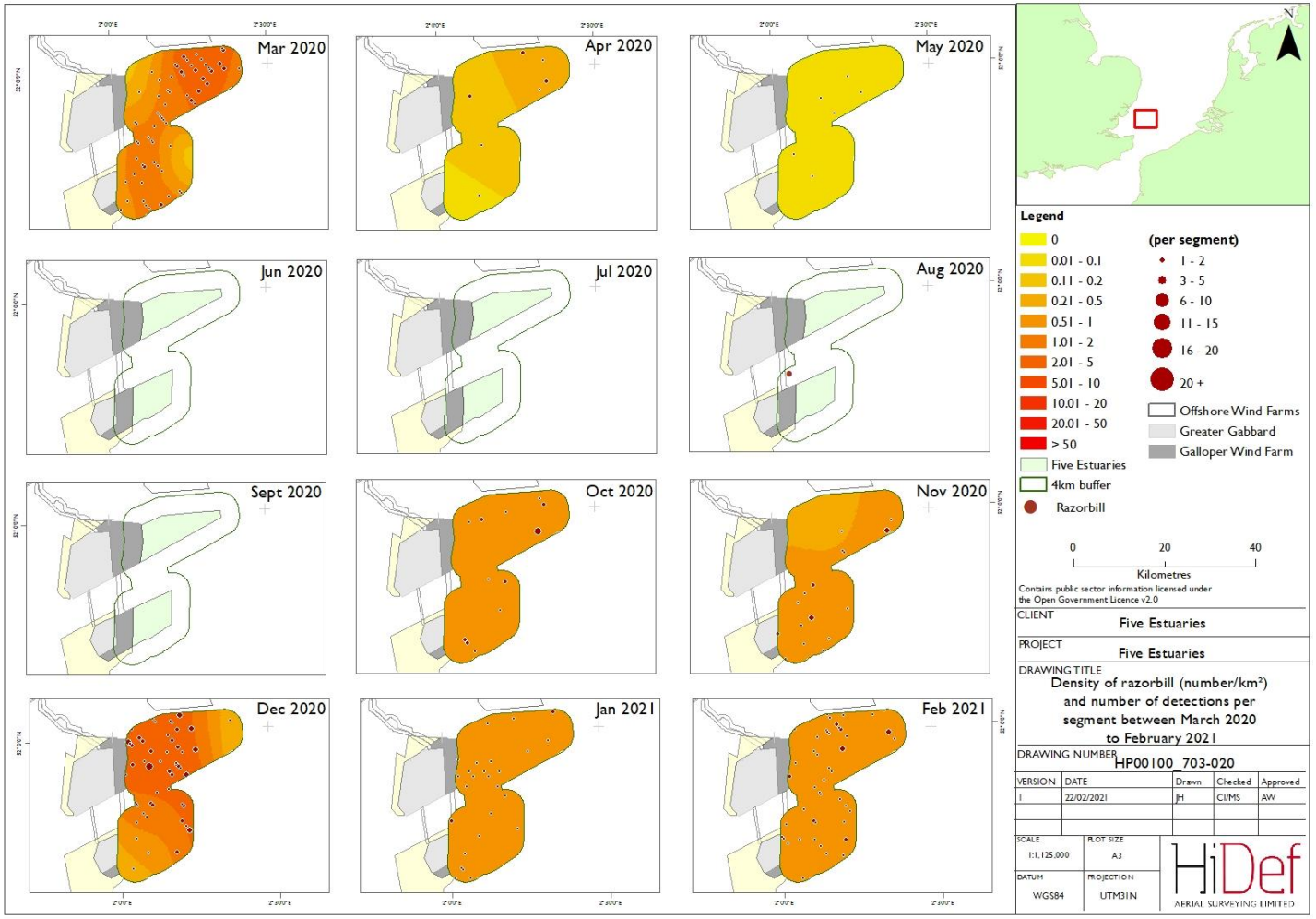


Table 30 Summary of razorbill behaviours between March 2019 and February 2020

Survey date	Number recorded diving	Number recorded flying	Number recorded landing	Number recorded sitting	Number recorded taking off	% Flying	Total
Mar-19	0	3	0	330	0	1%	333
Apr-19	0	0	0	46	0	0%	46
May-19	0	0	0	8	0	0%	8
Jun-19	0	0	0	0	0	0%	0
Jul-19	0	0	0	1	0	0%	1
Aug-19	0	0	0	2	0	0%	2
Sep-19	0	0	0	0	0	0%	0
Oct-19	0	0	0	50	0	0%	50
Nov-19	0	0	0	41	0	0%	41
Dec-19	0	1	0	289	0	0%	290
Jan-20	0	8	0	41	0	16%	49
Feb-20	0	26	0	204	0	11%	230
Mar-20	0	0	0	119	0	0%	119
Apr-20	0	1	0	15	0	6%	16
May-20	0	0	0	8	0	0%	8
Jun-20	0	0	0	0	0	0%	0
Jul-20	0	0	0	0	0	0%	0
Aug-20	0	0	0	1	0	0%	1
Sep-20	0	0	0	0	0	0%	0
Oct-20	0	19	0	21	0	48%	40
Nov-20	0	0	0	40	0	0%	40
Dec-20	0	0	0	170	0	0%	170
Jan-21	0	8	0	30	0	21%	38
Feb-21	0	8	0	73	0	10%	81
Total	**0**	**74**	**0**	**1489**	**0**	**5%**	**1563**

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Figure 47 Flying direction of razorbills observed between March 2019 and February 2020

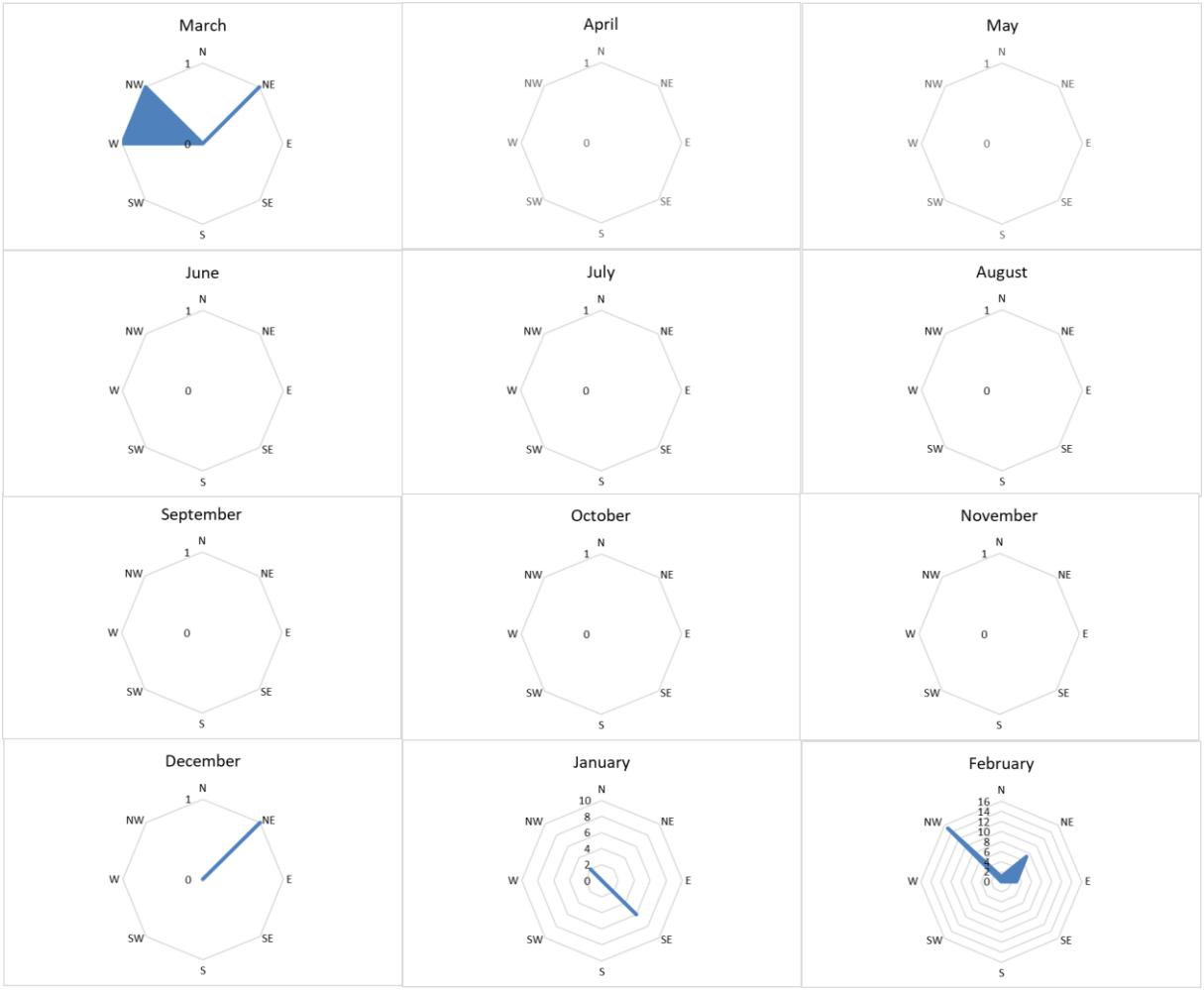
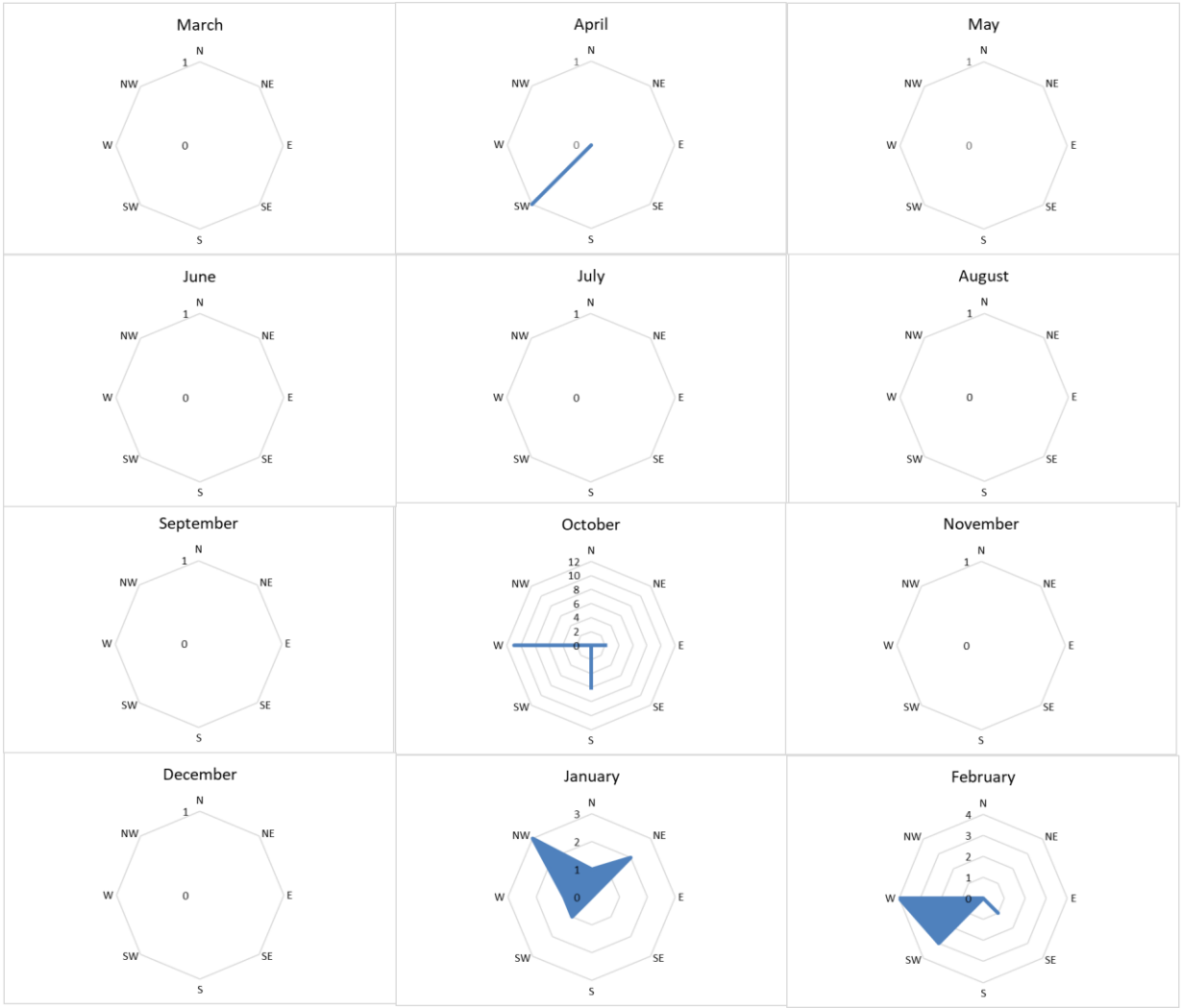


Figure 48 **Flying direction of razorbills observed between March 2020 and February 2021**



3.3.9 Less abundant bird species

98 Less abundant bird species were recorded sporadically throughout the year (Table 31; Figure 49; Figure 50). Density and abundance estimates can be found in Appendix I. Detections are shown in Figure 51 and Figure 52.

99 Red-throated divers were recorded in single figures, with a total of 18 records for the entire survey period. Birds were present across the wintering period, from as early as October and with individuals staying as late as May. Birds were observed in the proposed array site in December 2019, February 2020 and January and February 2021. All other observations occurred within the buffer.

100 Only two Sandwich terns were observed across the entire survey period; in April and October 2019. These birds were present in the central buffer area and the lower proposed array site.

Table 31 Number of less abundant bird species recorded between March 2019 and February 2021

Survey	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Year 1 Total
Less abundant birds	8	4	0	14	12	10	12	8	8	3	4	10	93
Survey	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Year 2 Total**
Less abundant birds	10	22	4	4	25	1	20	51	1	14	7	9	168

Figure 49 **Number of less abundant bird species observed between March 2019 and February 2020**

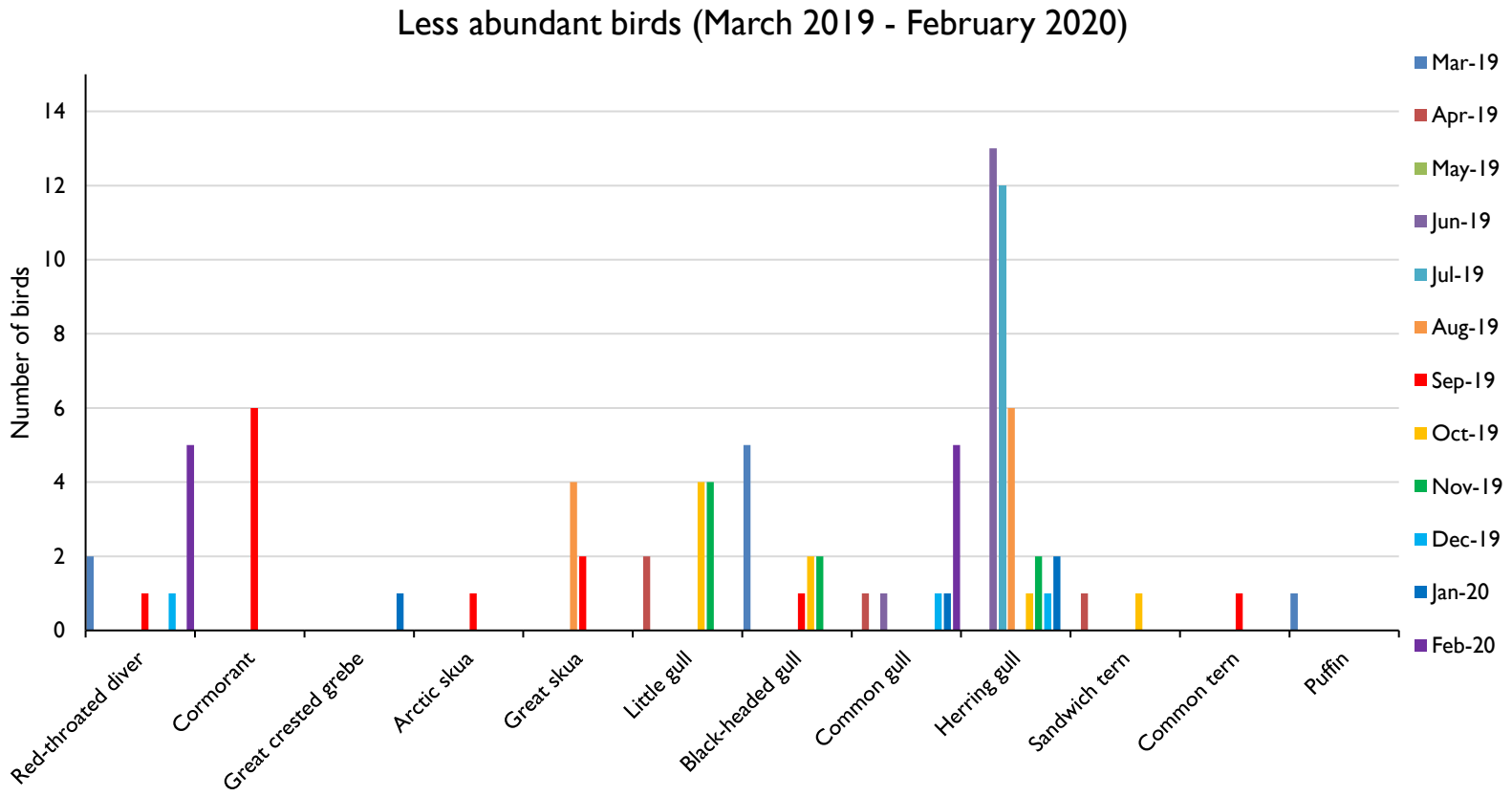


Figure 50 **Number of less abundant bird species observed between March 2020 and February 2021**

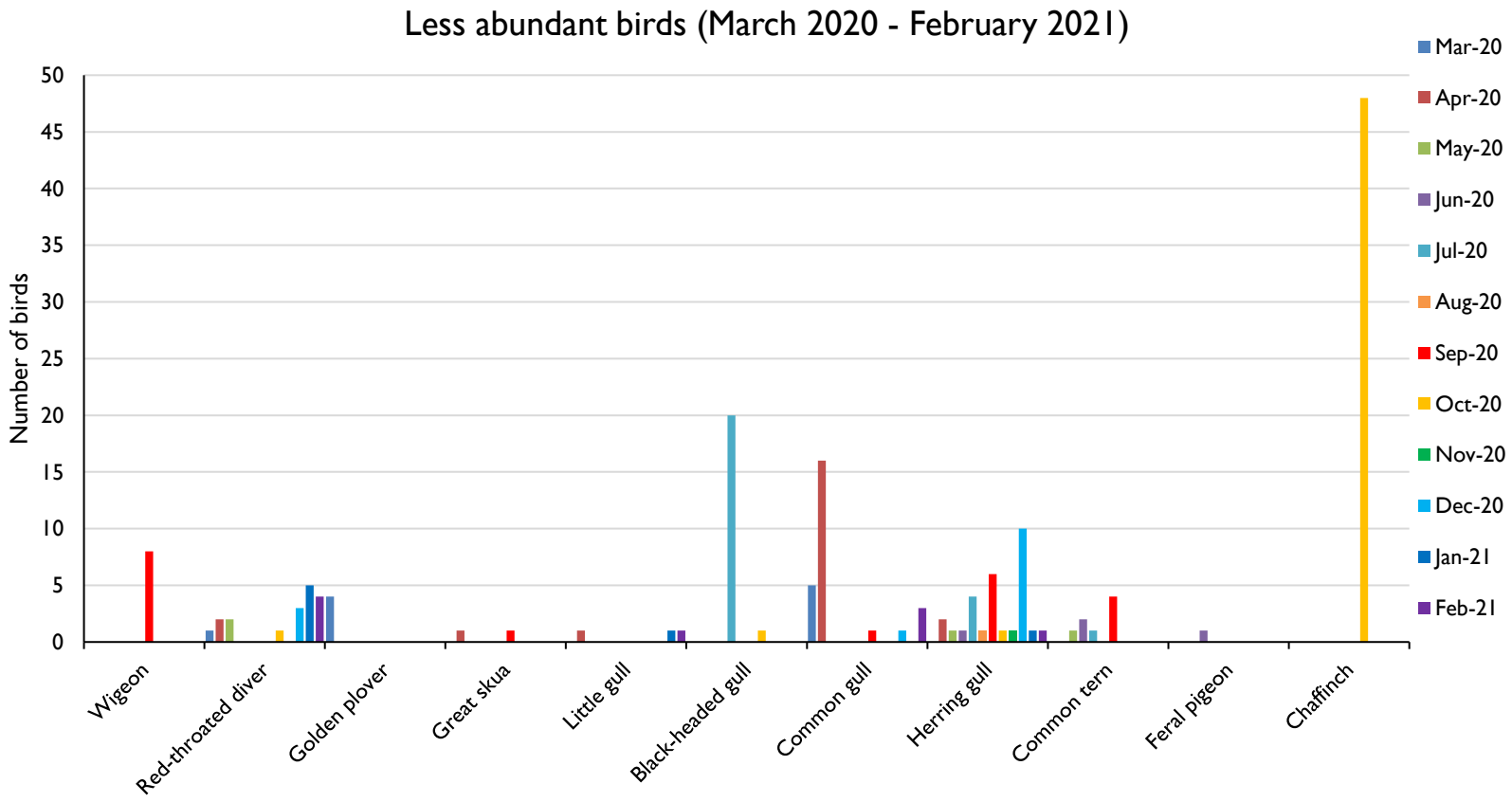


Figure 51 Detections of less abundant bird species between March 2019 and February 2020

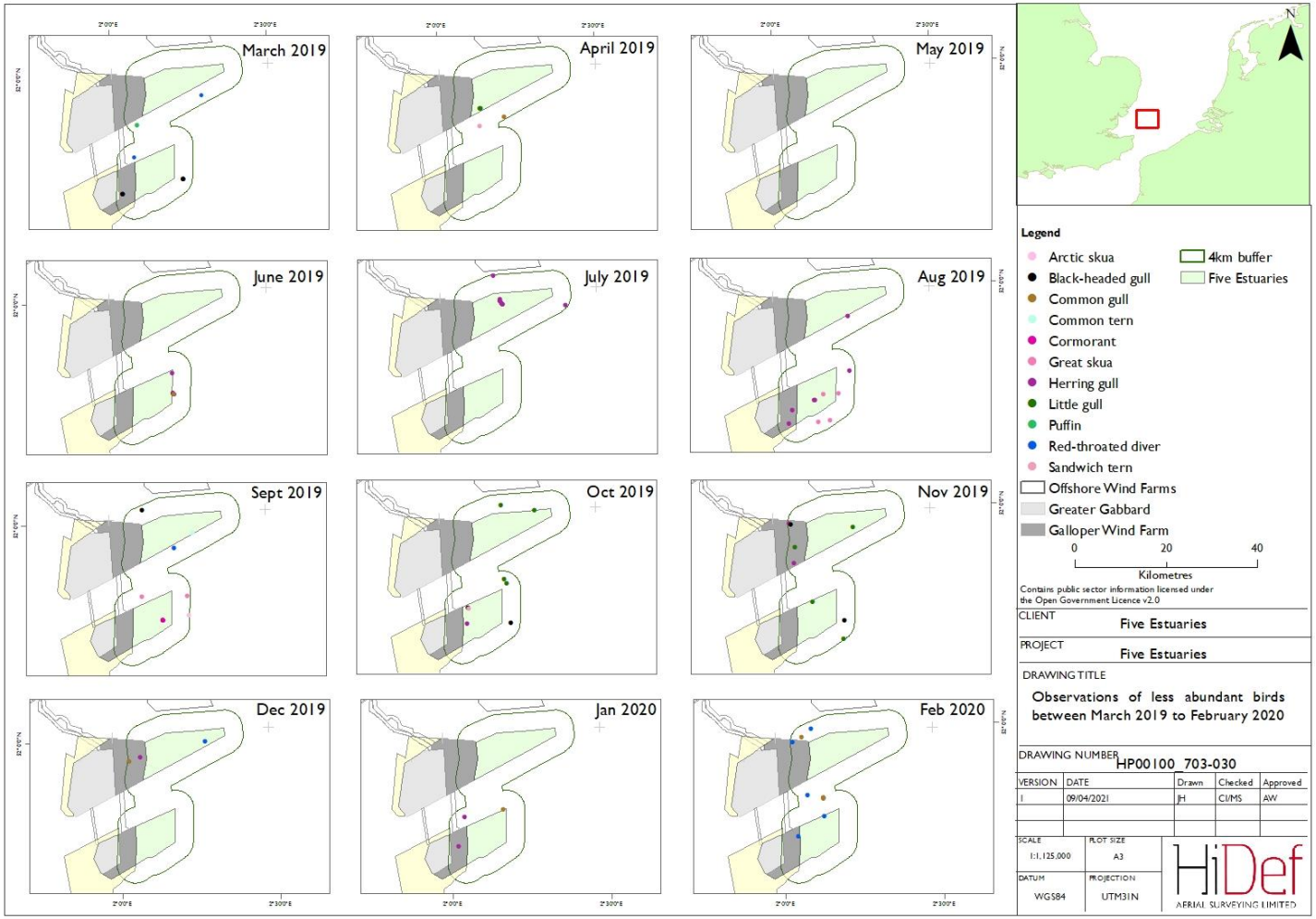
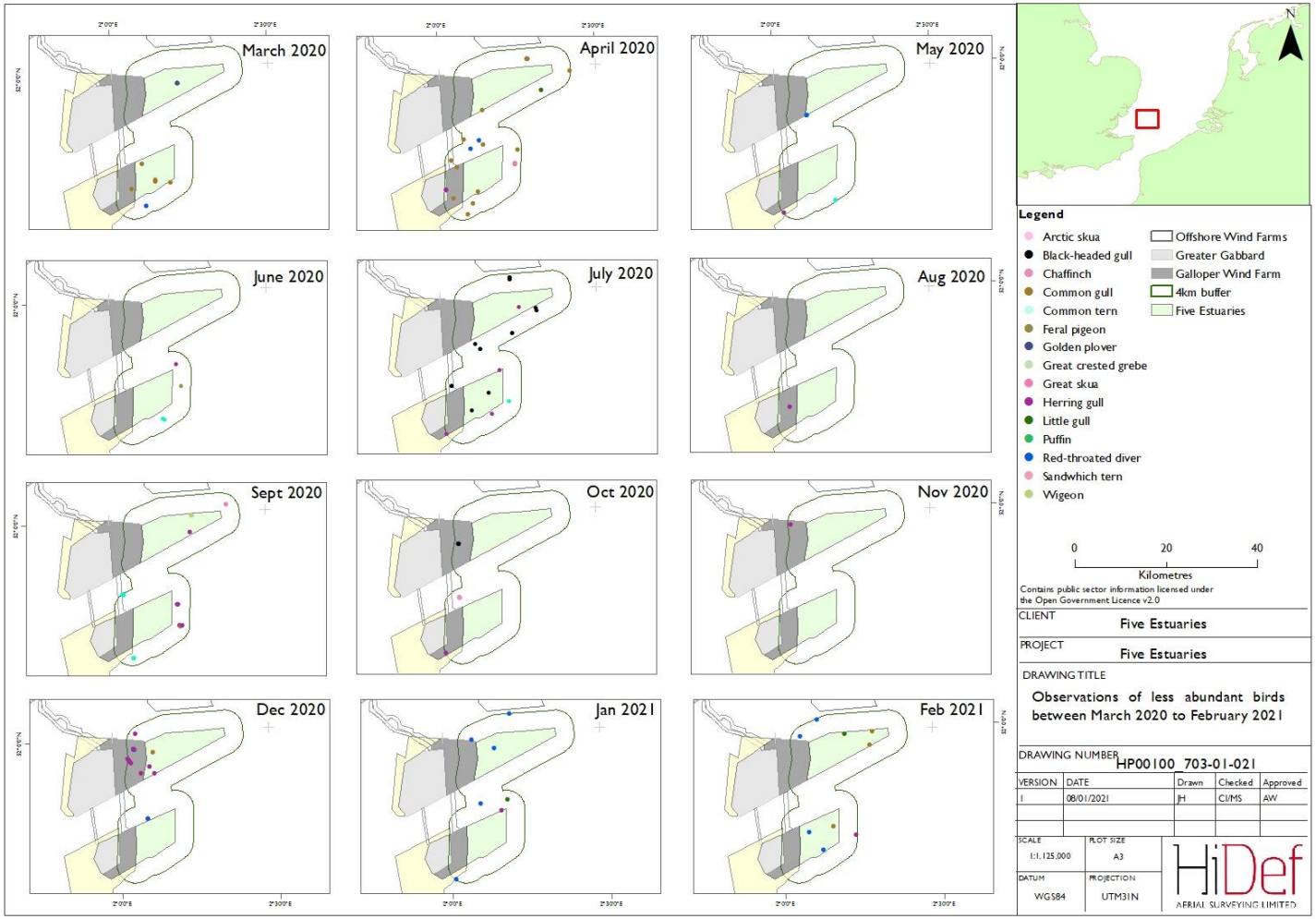


Figure 52 Detections of less abundant bird species between March 2020 and February 2021



3.3.10 Partially identified birds

101 The numbers of partially identified birds (those assigned to species group but not species) observed across the survey programme are presented in Table 32. Detections are shown in Figure 55 and Figure 56. The autumn peaks of partial identification relate primarily to difficulties differentiating between razorbill and guillemot (Figure 53; Figure 54). These are especially problematic to identify in autumn when juvenile birds are more abundant. Additionally, the partial-identification peaks for fulmar/gull species in August and September coincide with increased influxes of fulmars in these months. These observations relate exclusively to sitting birds. Fulmars can be harder to distinguish between gulls of a similar size at certain angles when sat on the water.

Table 32 Number of partially identified birds recorded between March 2019 to February 2020

Survey	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Year 1 Total
Partially identified birds	49	20	11	12	3	42	43	20	27	55	28	167	477
Survey	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Year 2 Total**
Partially identified birds	19	18	11	15	6	1	15	2	21	90	27	64	290

Figure 53 Number of partially identified birds observed between March 2019 and February 2020

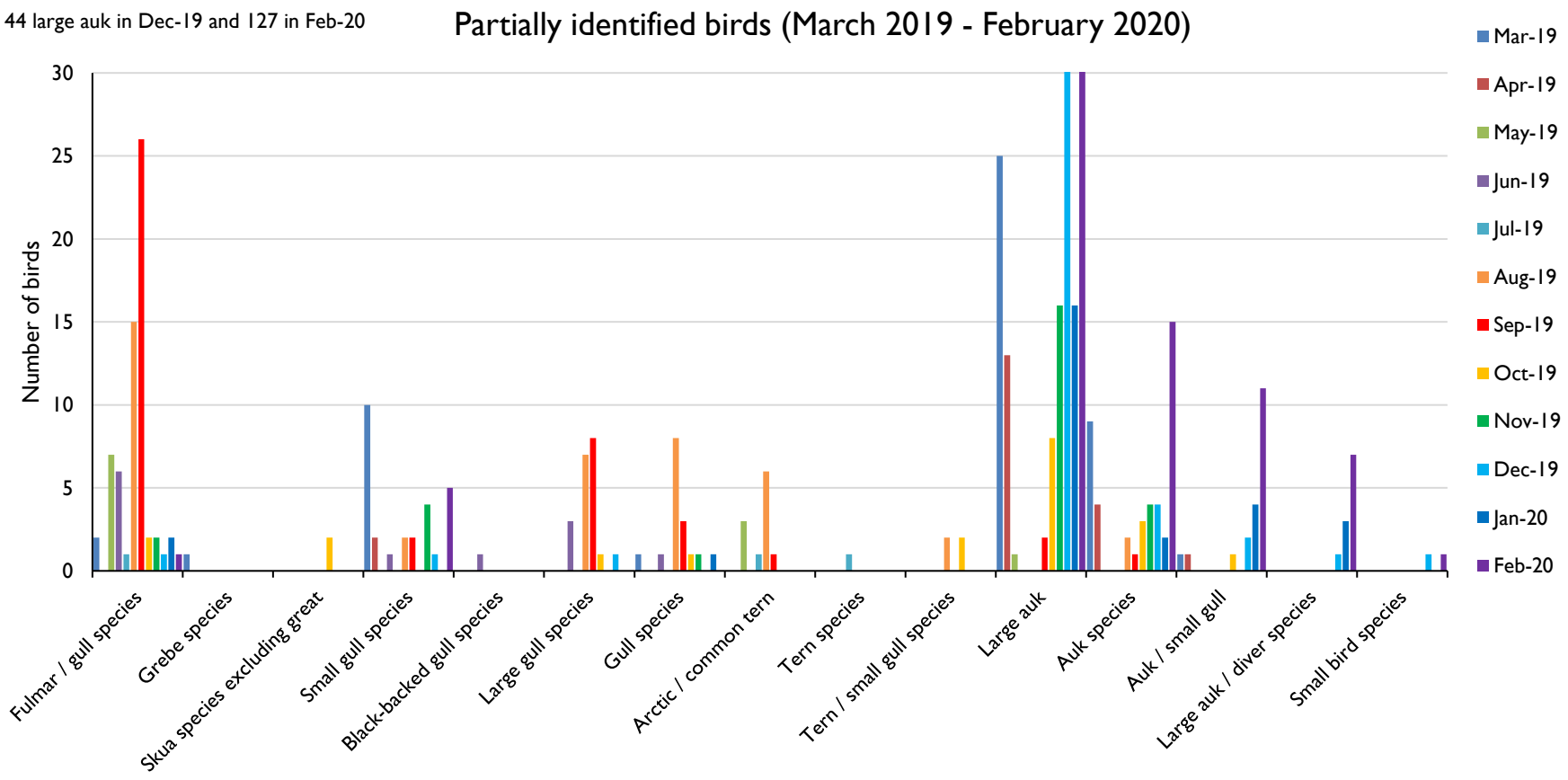


Figure 54 **Number of partially identified birds observed between March 2020 and February 2021**

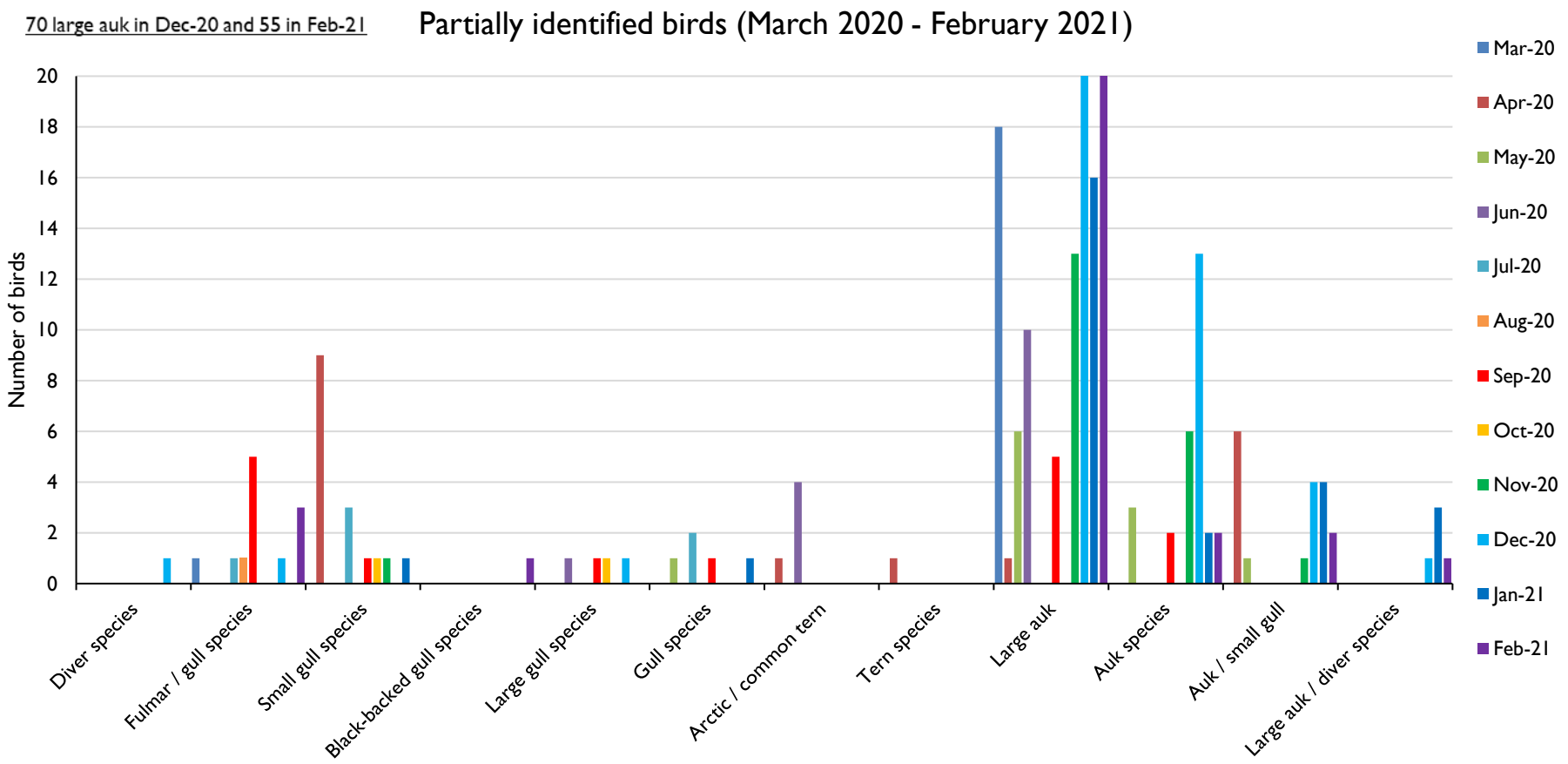


Figure 55 Detections of partially identified birds between March 2019 and February 2020

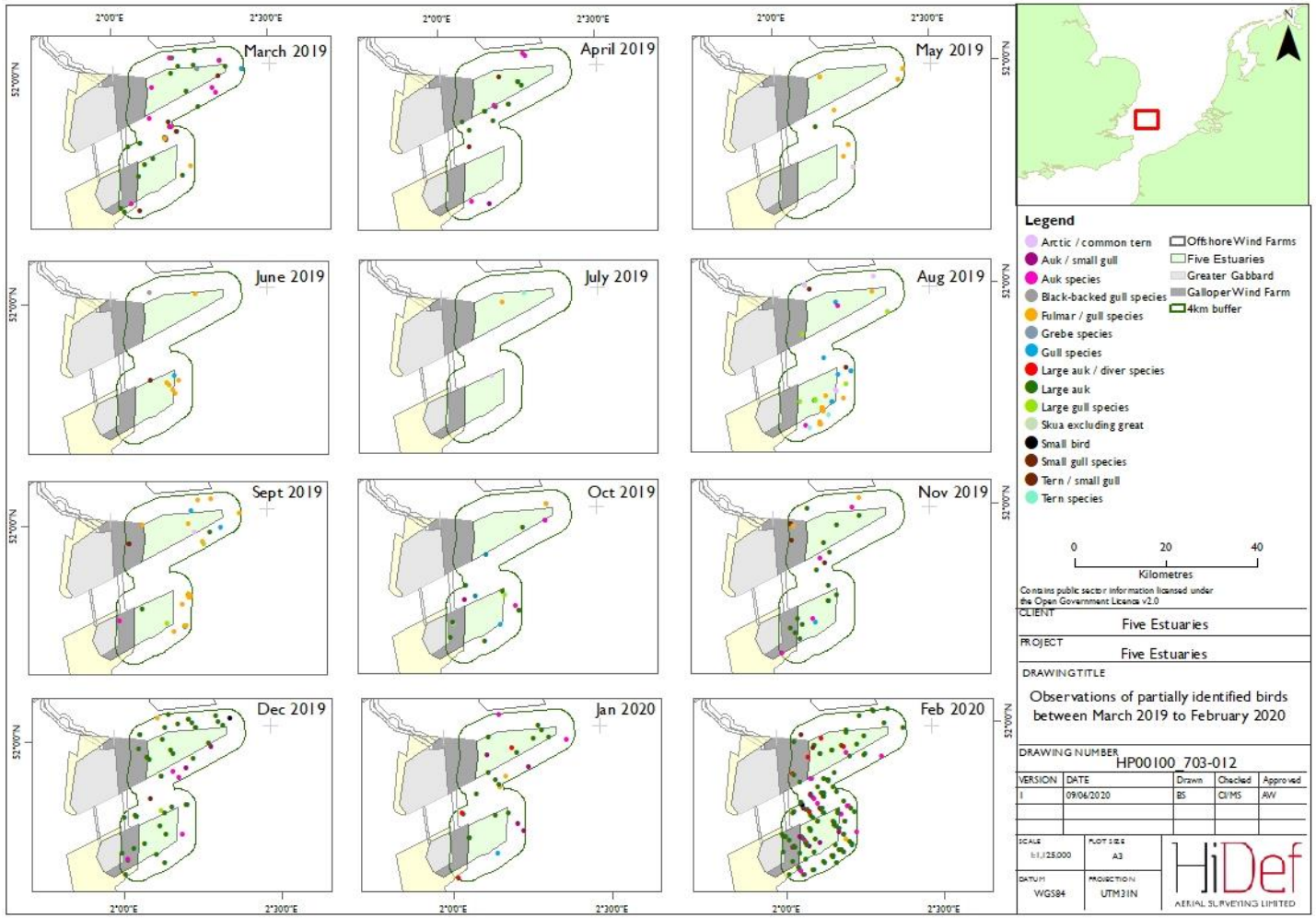
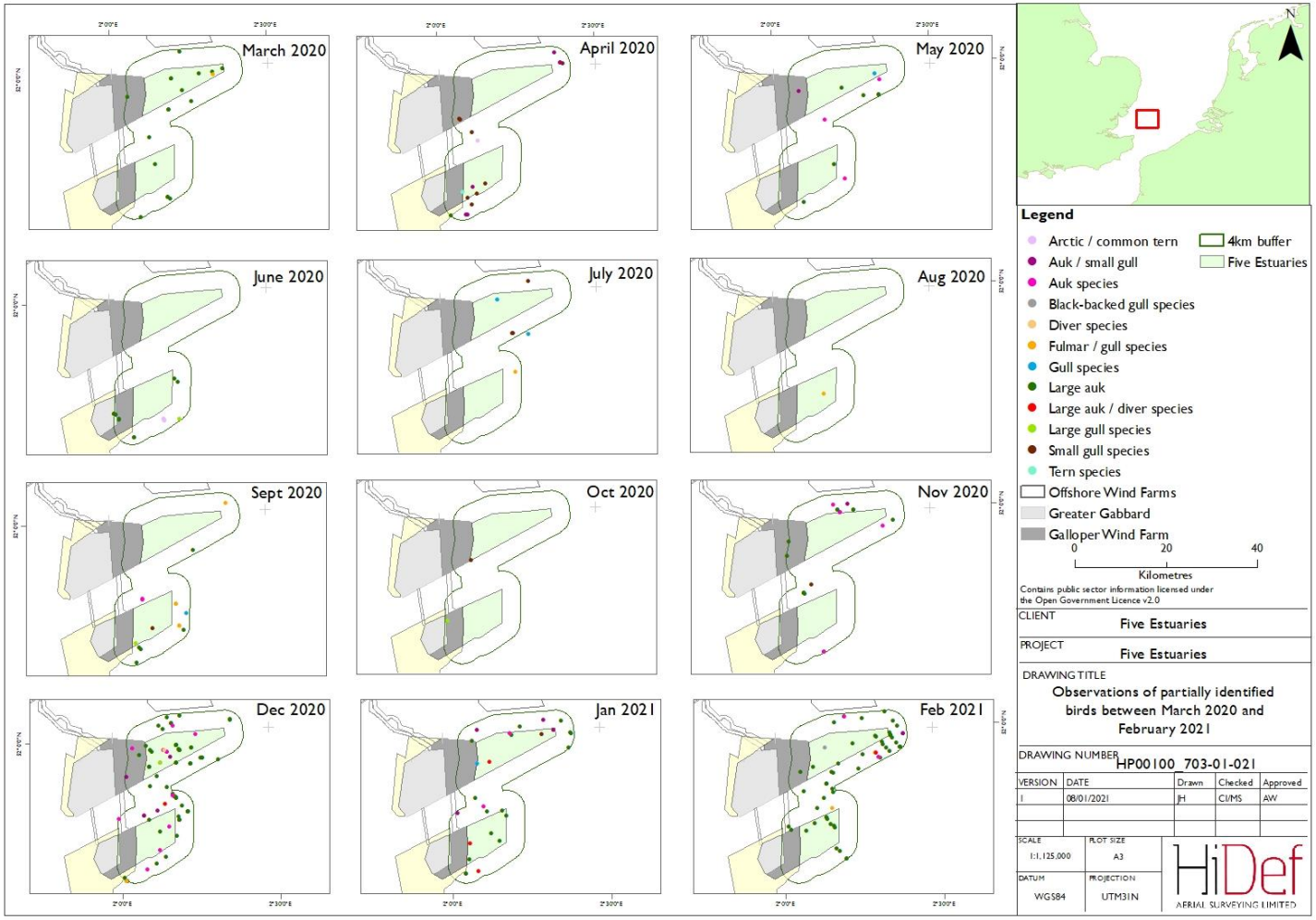


Figure 56 **Detections of partially identified birds between March 2020 and February 2021**



3.3.11 All non-avian animals

102 Non-avian animals were present throughout the survey period, with peaks in abundance in the autumn and spring (Table 33; Figure 57). The monthly density maps for all non-avian animals combined show widespread observations throughout the survey area, such as in November 2019 and May 2020 (Figure 58; Figure 59).

103 A summary of surfacing behaviour for all non-avian animals is presented in Table 34.

Table 33 Number of non-avian animals recorded between March 2019 and February 2021

Survey	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Year 1 Total
All non-avian animals	28	6	3	13	10	49	46	12	78	17	5	18	285
Survey	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Year 2 Total**
All non-avian animals	34	27	99	19	27	6	34	12	29	12	16	22	337

Figure 57 Number of non-avian animals recorded between March 2019 and February 2021

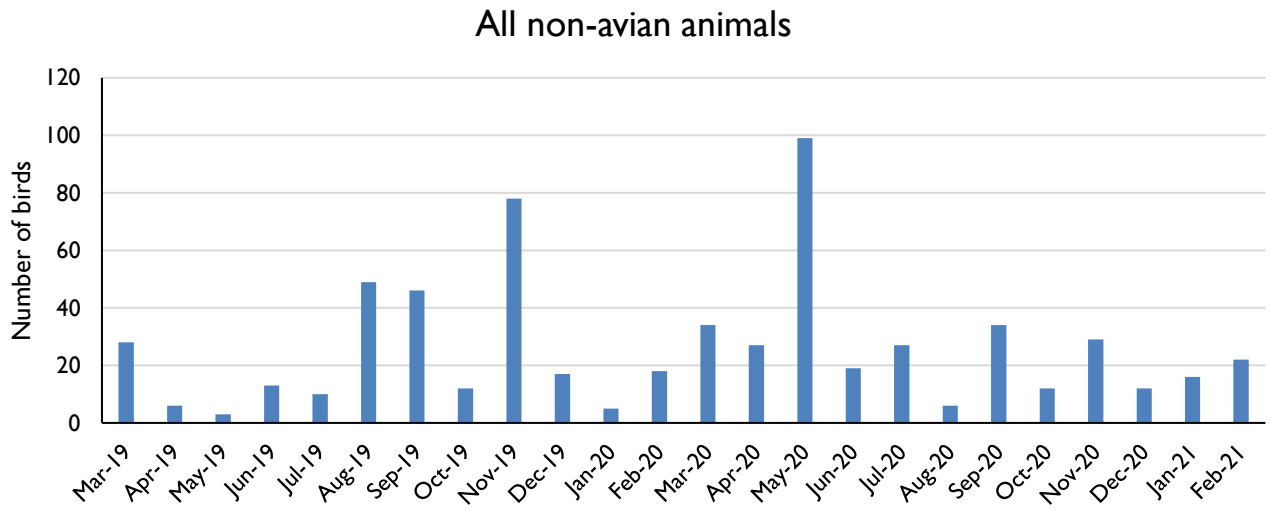


Table 34 Summary of surfacing behaviour for all non-avian animals between March 2019 and February 2021

Species	Submerged	Surfacing	Snapshot surfacing	Unknown	% Surfacing	Total
Grey seal	2	2	4	0	50%	8
Harbour porpoise	357	49	156	13	27%	575
No ID						
Seal species	8	1	17	2	61%	28
Seal / small cetacean species	5	2	0	2	0%	9
Cetacean species	1	1	0	0	0%	2
Total	**373**	**55**	**177**	**17**	**28%**	**622**

Figure 58 **Density of all non-avian animals (number/km²) and number of detections per segment between March 2019 and February 2020**

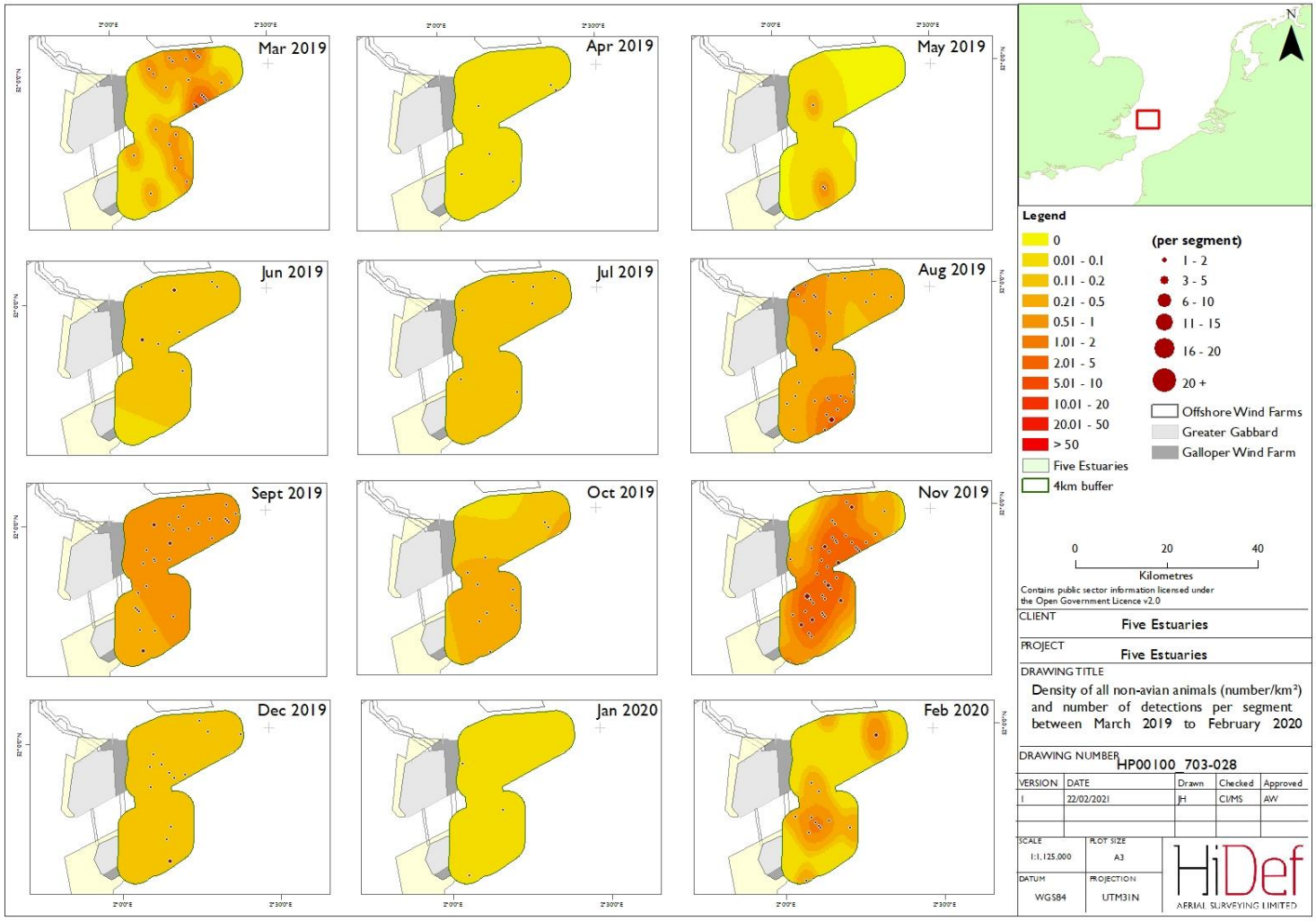
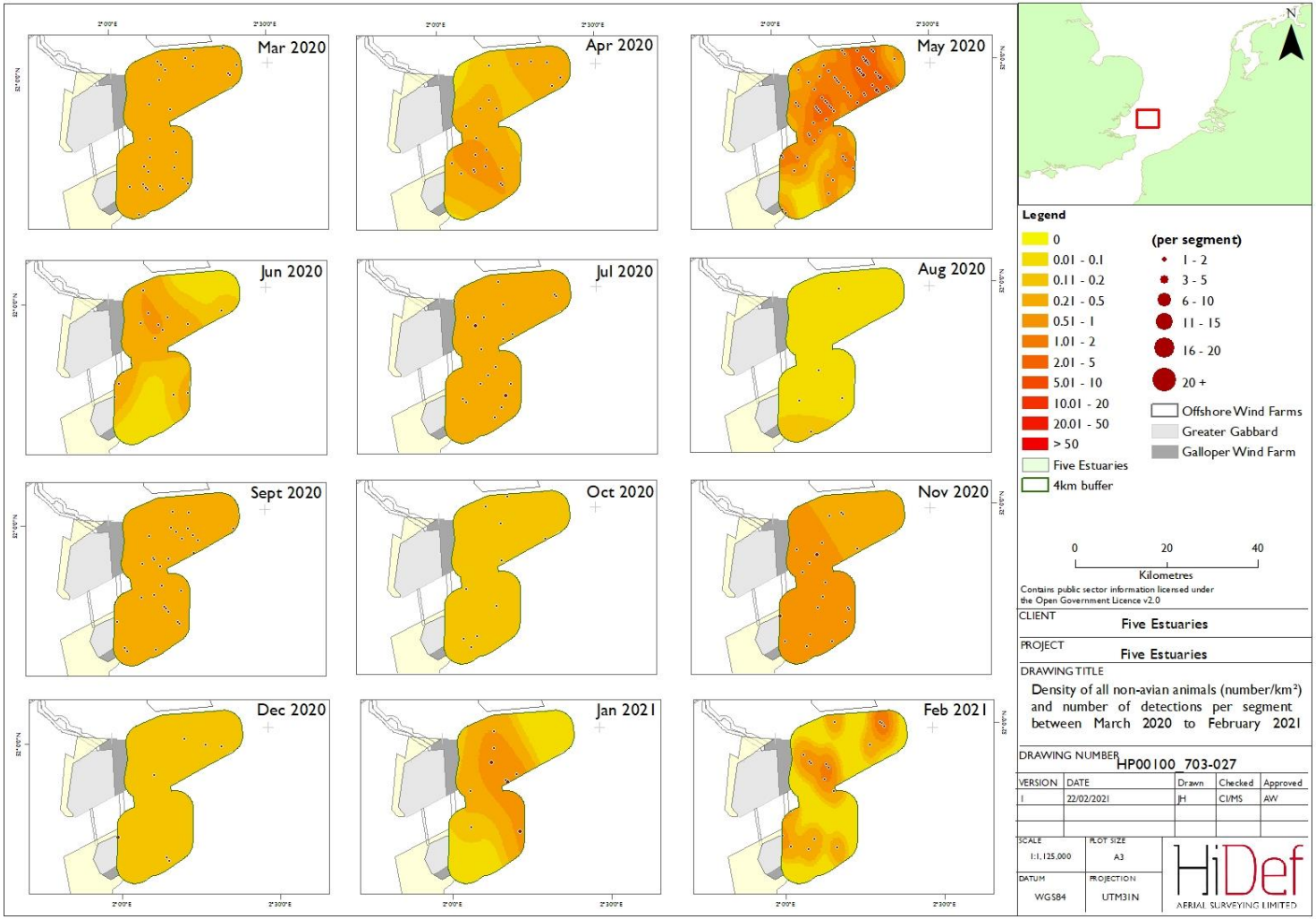


Figure 59 **Density of all non-avian animals (number/km²) and number of detections per segment between March 2020 and February 2021**



3.3.12 Harbour porpoise

104 Harbour porpoise were the most abundant non-avian animal species, observed in all surveys throughout the study period, with notable peaks recorded in November 2019 and May 2020 (Table 35; Figure 60).

105 Absolute density and abundance was estimated at moderate to high levels, with notably high estimates in late summer and autumn (Figure 61). Harbour porpoise reached a peak density of 8.48 animals/km^2 in November 2019, equating to 5,160 animals (±95% CI 3,418 – 6,955). In the subsidiery peak in May 2020, density was estimated at 5.2 animals/km^2, equating to 3,148 animals (±95% CI 1,805 – 4,722). Outside of these months, absolute density ranged between 0.14 and 3.10 animals/km^2, with population estimates ranging between 96 animals (±95% CI 0 - 245) and 1,865 animals (±95% CI 1,413 – 2,342).

106 Harbour porpoise had varied distributions throughout the survey area, with high densities observed in the north-east of the survey area in March 2019 and May 2020 (Figure 62). In some months, low numbers of harbour porpoise were recorded, leading to no clear patterns in distributions in April and May 2019 and August 2020. Porpoise were widespread across the survey area in many months, such as in March, April and September 2020 (Figure 63). In January 2021, the species was primarily concentrated to the north and south-east of the survey area.

Table 35 Number of harbour porpoise recorded between March 2019 and February 2021

Survey	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Year 1 Total
Harbour porpoise	23	6	3	13	10	46	43	10	77	12	4	15	262
Survey	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Year 2 Total**
Harbour porpoise	32	25	96	17	26	4	32	12	28	10	15	16	313

Figure 60 Number of harbour porpoise recorded between March 2019 and February 2021

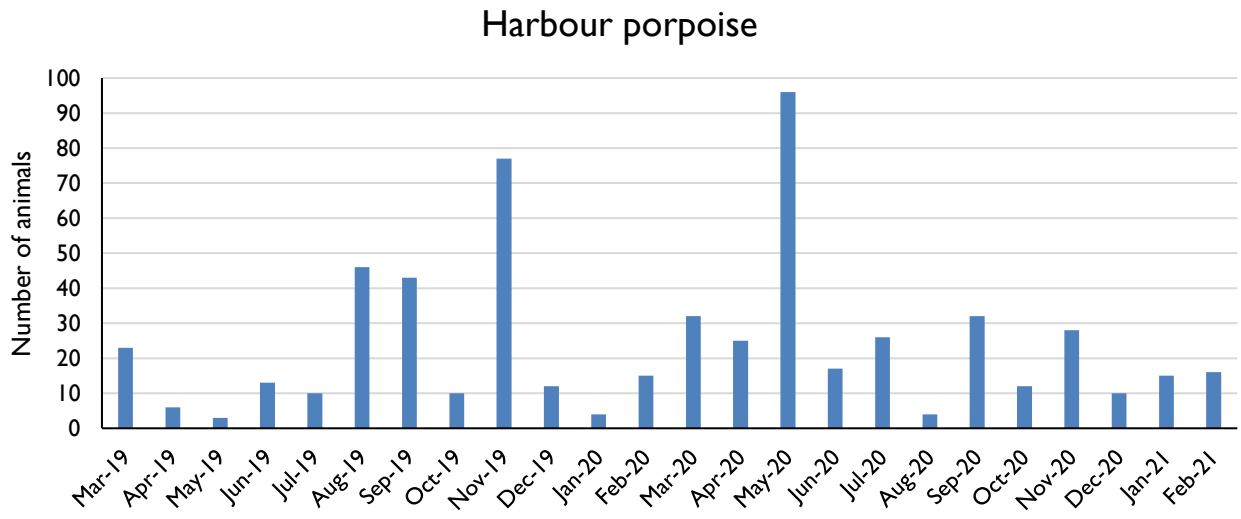


Figure 61 **Harbour porpoise absolute density estimates with lower and upper 95% confidence intervals between March 2019 and February 2021**

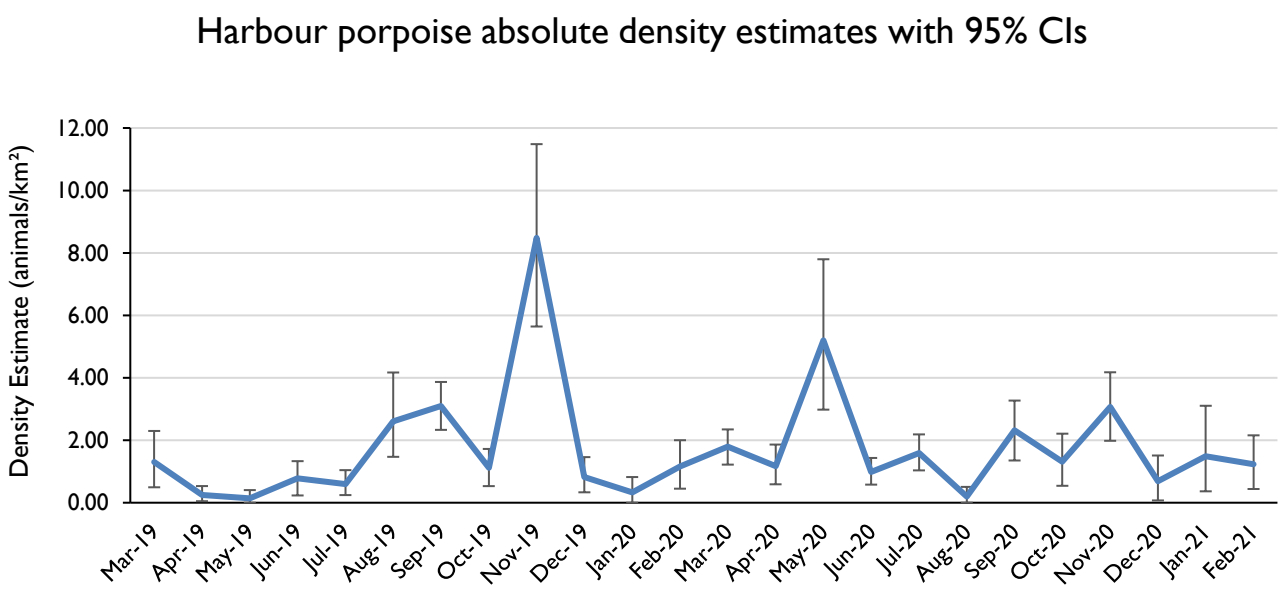


Figure 62 **Density of harbour porpoise (number/km²) and number of detections per segment between March 2019 and February 2020**

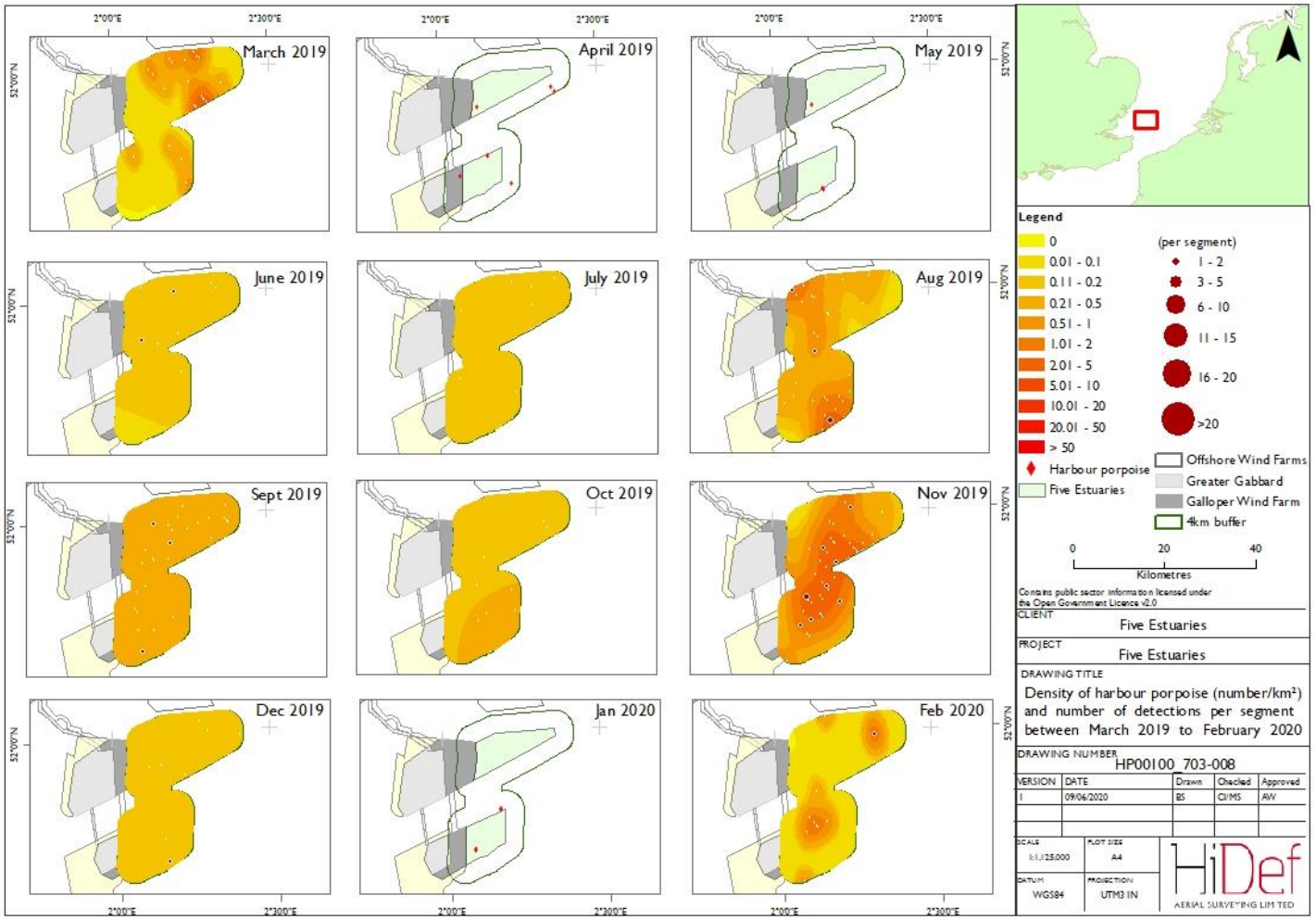
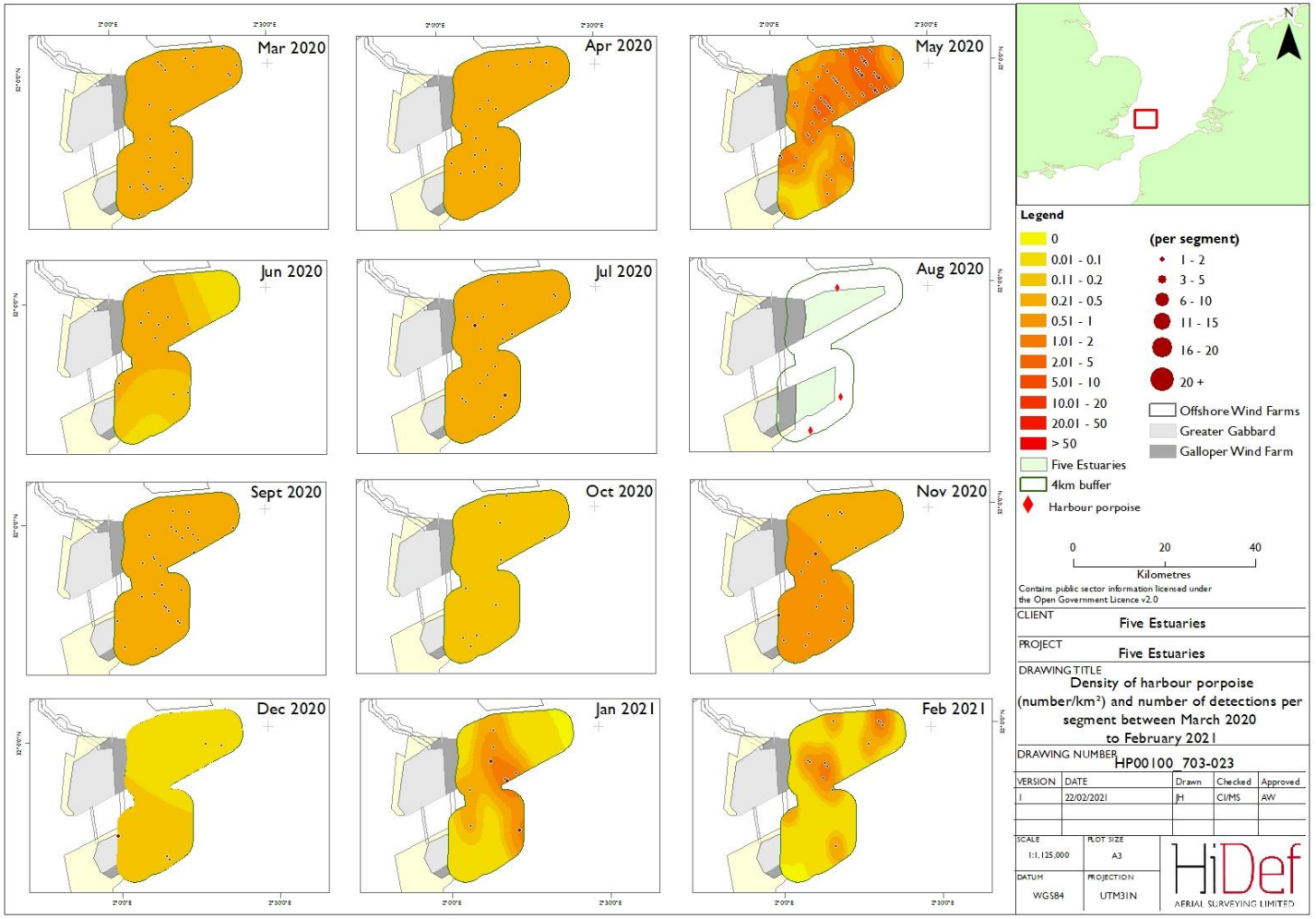


Figure 63 **Density of harbour porpoise (number/km²) and number of detections per segment between March 2020 and February 2021**



3.3.13 Less abundant non-avian animal species

107 The only other non-avian animal species observed during the survey period was grey seal *Halichoerus grypus*. No more than two individuals were observed per survey, appearing intermittently throughout the study period (Table 36; Figure 64). Over the entire two-year period, eight grey seals were recorded. The spatial distribution of observations are presented in Figure 65 and Figure 66. Some animals were recorded within the VE proposed site.

Table 36 Number of less abundant non-avian animals recorded between March 2019 and February 2021

Survey	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Year 1 Total
Grey seal	1	0	0	0	0	2	0	0	0	0	0	1	4
Survey	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Year 2 Total**
Grey seal	0	1	0	0	0	1	0	0	0	1	0	1	4

Figure 64 Number of less abundant non-avian animal species observed between March 2019 and February 2021

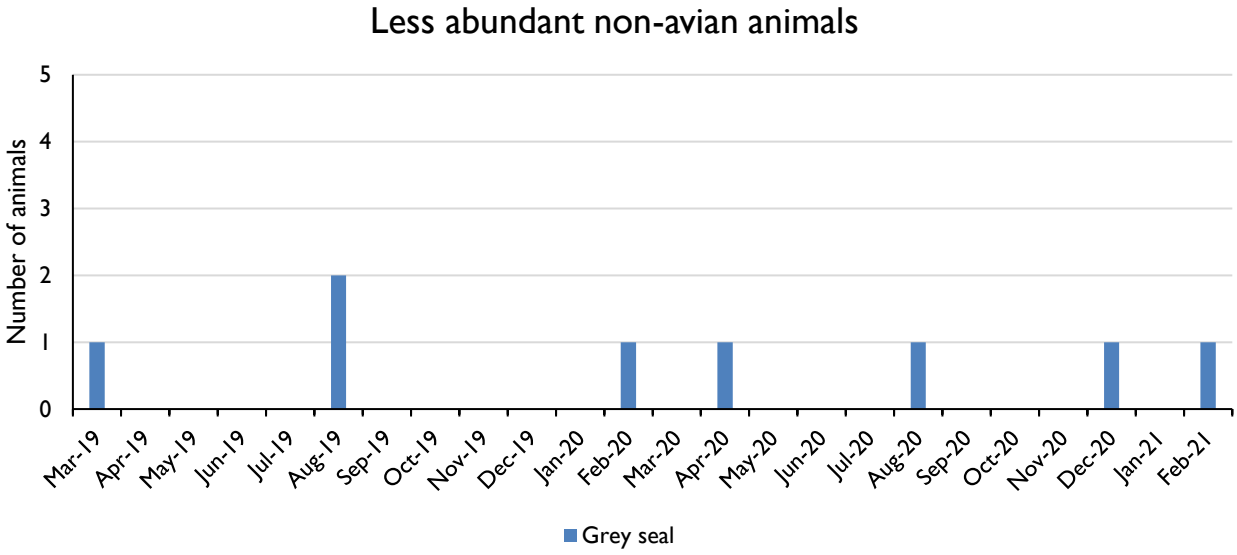


Figure 65 **Detections of less abundant non-avian species between March 2019 and February 2020**

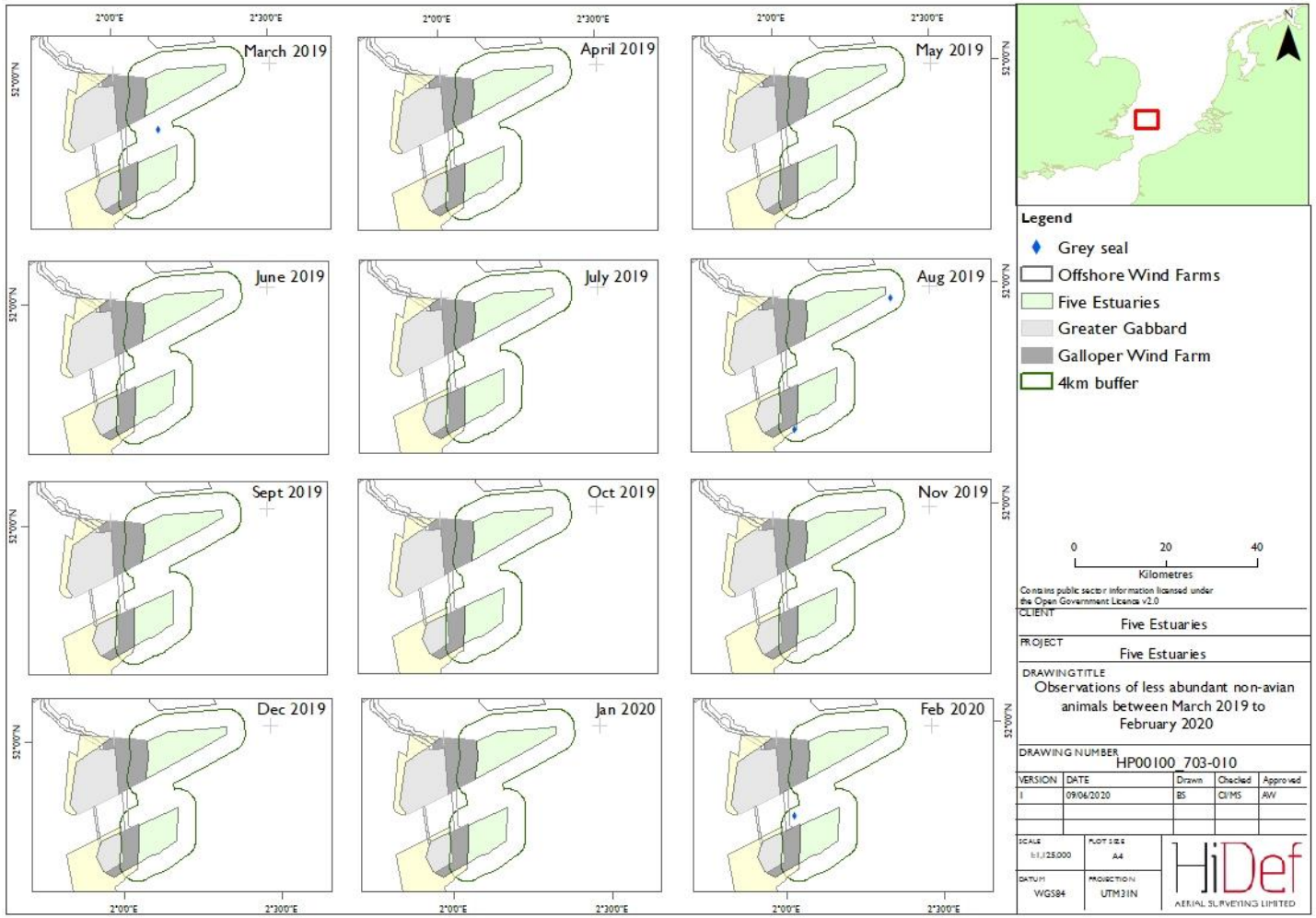
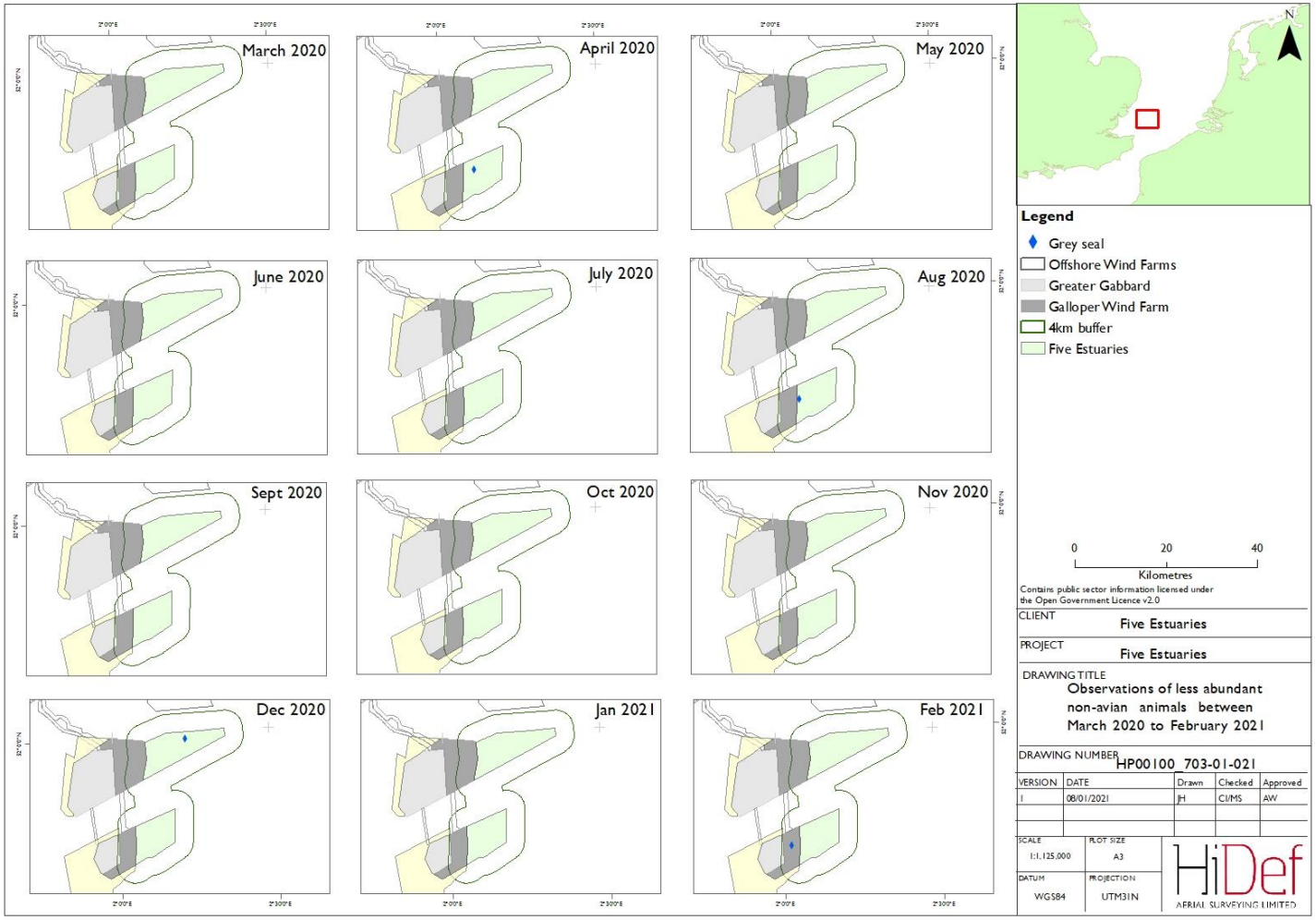


Figure 66 **Detections of less abundant non-avian species between March 2020 and February 2021**



3.3.14 Partially identified non-avian animals

108 Low numbers of partially identified non-avian animals were observed in most months through the survey period (Table 37; Figure 67). The spatial distribution of observations is shown in Figure 68 and Figure 69. Most partial identifications can be attributed to difficulty discerning between grey seal and harbour seal *Phoca vitulina*. Whilst this can be very apparent for bull grey seals due to their large size and pronounced muzzles, identification can be harder for females where body length overlaps and discerning characteristics, such as pelt and muzzle, may be concealed if the animal is submerged.

Table 37 Number of partially identified non-avian animals recorded between March 2019 and February 2021

Survey	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Year 1 Total
Partially identified non-avian animals	4	0	0	0	0	1	3	2	1	5	1	2	19
Survey	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Year 2 Total**
Partially identified non-avian animals	2	1	3	2	1	1	2	0	1	1	1	5	20

Figure 67 Number of partially identified non-avian animals observed between March 2019 and February 2021

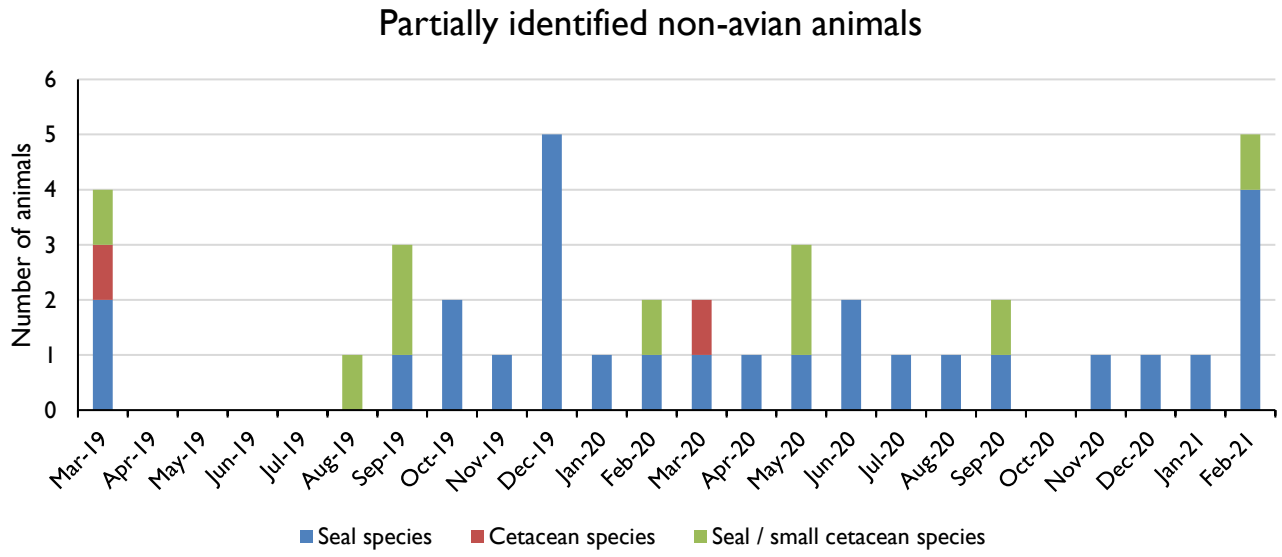


Figure 68 **Detections of partially identified non-avian animals between March 2019 and February 2020**

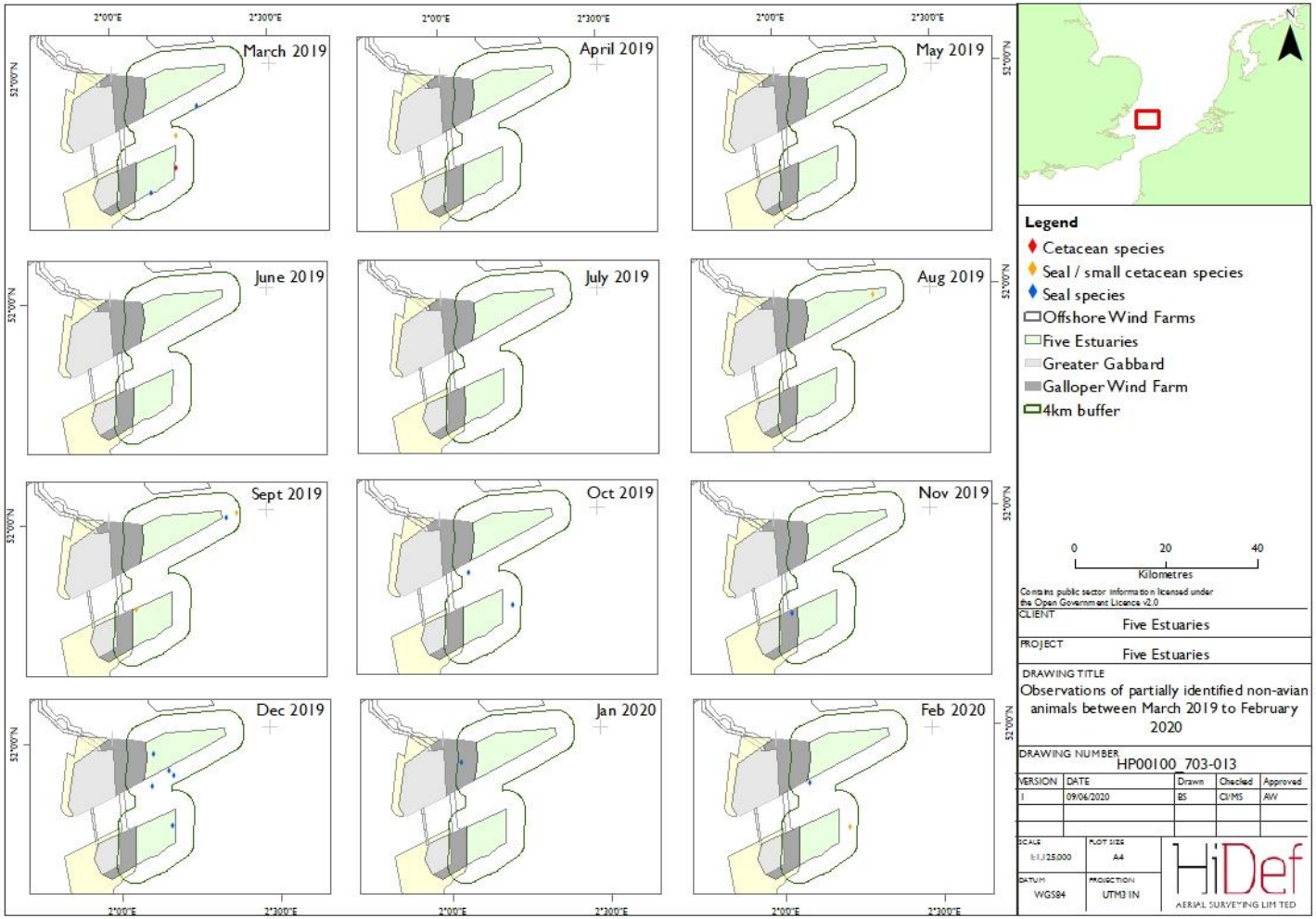
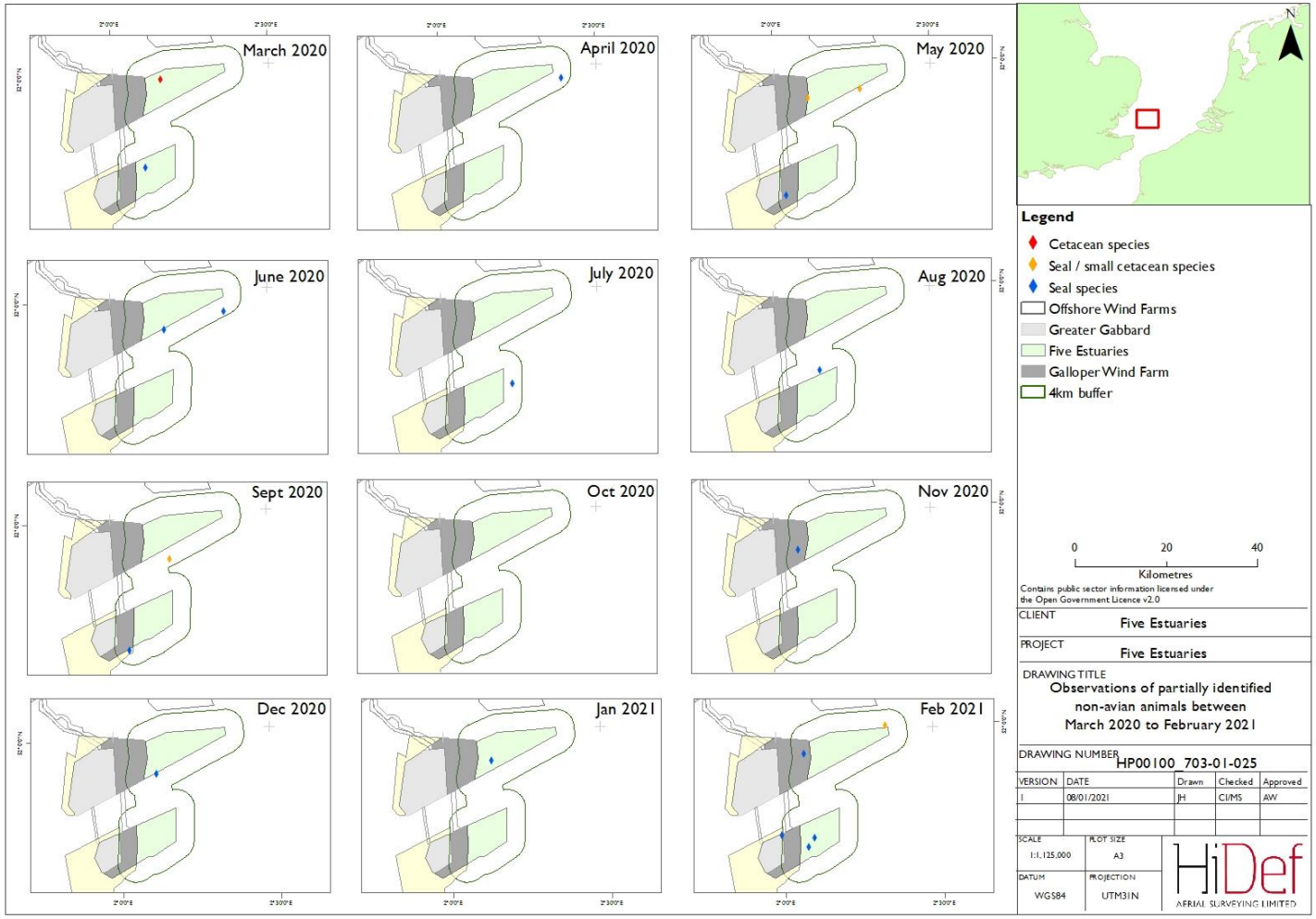


Figure 69 **Detections of partially identified non-avian animals between March 2020 and February 2021**



3.3.15 Anthropogenic activity

109 Anthropogenic activity, such as man-made objects and vessel traffic, was observed throughout the survey period (Table 38; Figure 70). Detections are shown in Figure 71 and Figure 72.

110 Four fishing boats were recorded during the two-year period, all present in June 2019. Fishing boats were mainly distributed around the Five Estuaries site boundary or within the Galloper Wind Farm area. Other boats were observed intermittently throughout the survey period, distributed in the buffer zone and within the Galloper Wind Farm area. Considerably more non-fishing type vessels were recorded during Year 2.

111 Man-made objects were recorded in all surveys, with at least 67 out of 381 observations relating to fishing buoys or equipment. The majority of man-made objects were distributed to the west of the survey area, with some also in the north, such as in January and June 2020. The majority of man-made objects, especially those in the west of the survey area, were related to wind turbine generators, accounting for 120 and 100 records in Years 1 and 2 respectively.

Table 38 Number of anthropogenic objects recorded between March 2019 and February 2021

Survey	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Year 1 Total
Fishing Boat	0	0	0	4	0	0	0	0	0	0	0	0	4
Man-made object	24	24	18	13	19	13	15	13	24	19	12	11	205
Other boat	1	1	1	0	0	1	0	0	0	0	0	3	7
Survey	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Year 2 Total**
Fishing Boat	0	0	0	0	0	0	0	0	0	0	0	0	0
Man-made object	15	20	16	16	21	6	19	6	14	10	13	20	176
Other boat	1	0	0	11	1	0	0	0	0	3	0	2	18

Figure 70 Number of anthropogenic objects observed between March 2019 and February 2021

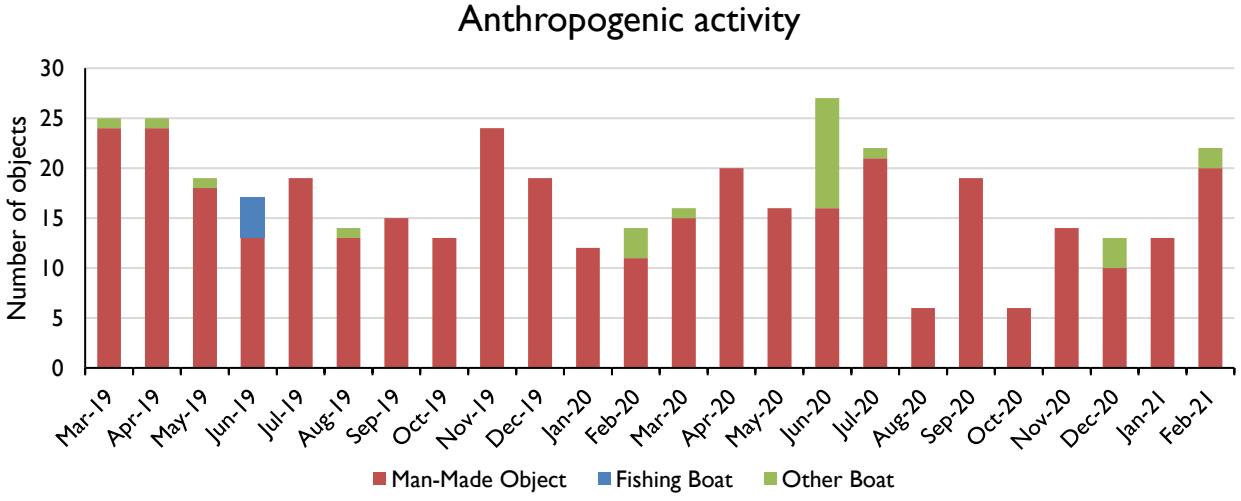


Figure 71 **Detections of vessels and anthropogenic objects between March 2019 and February 2020**

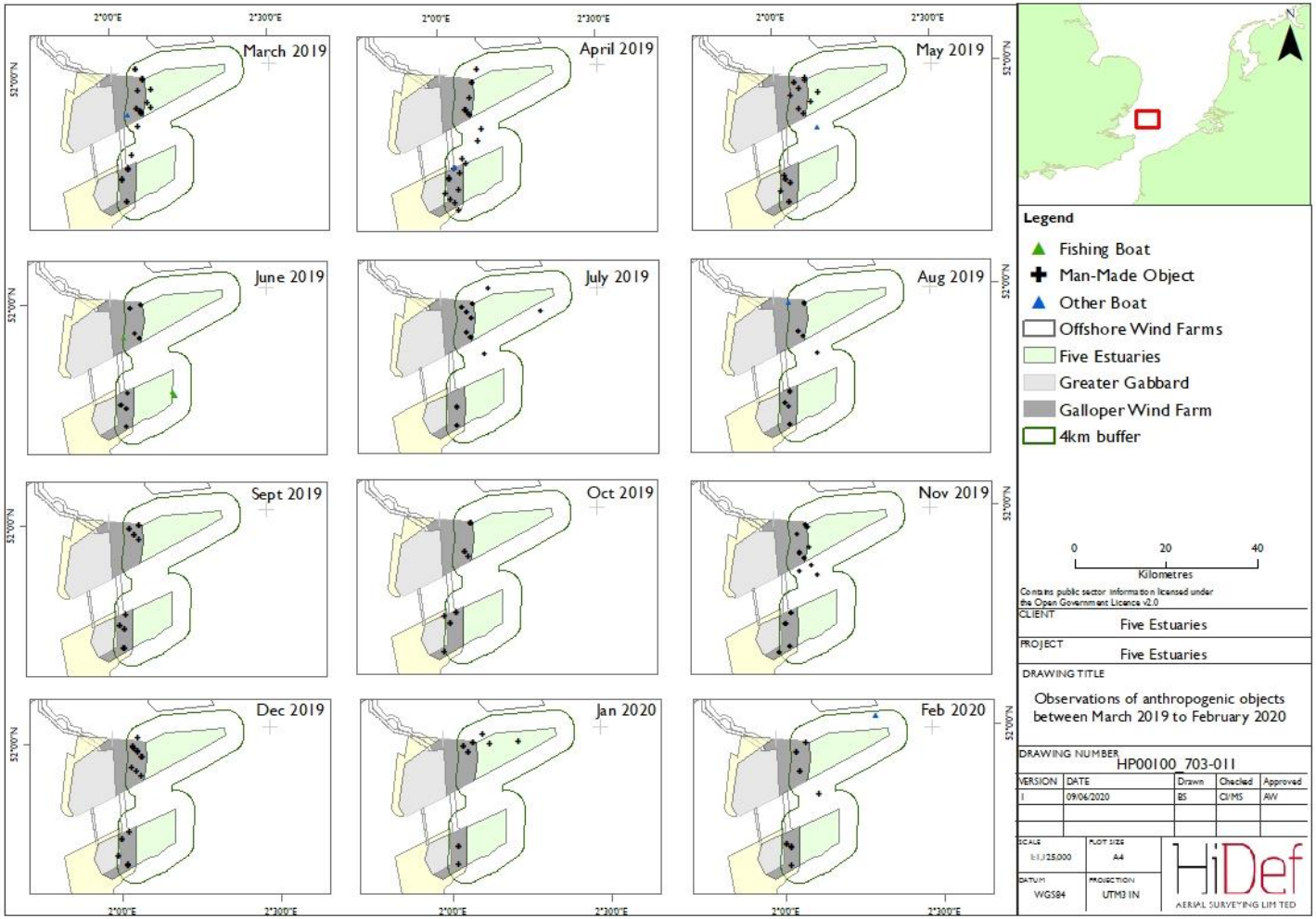
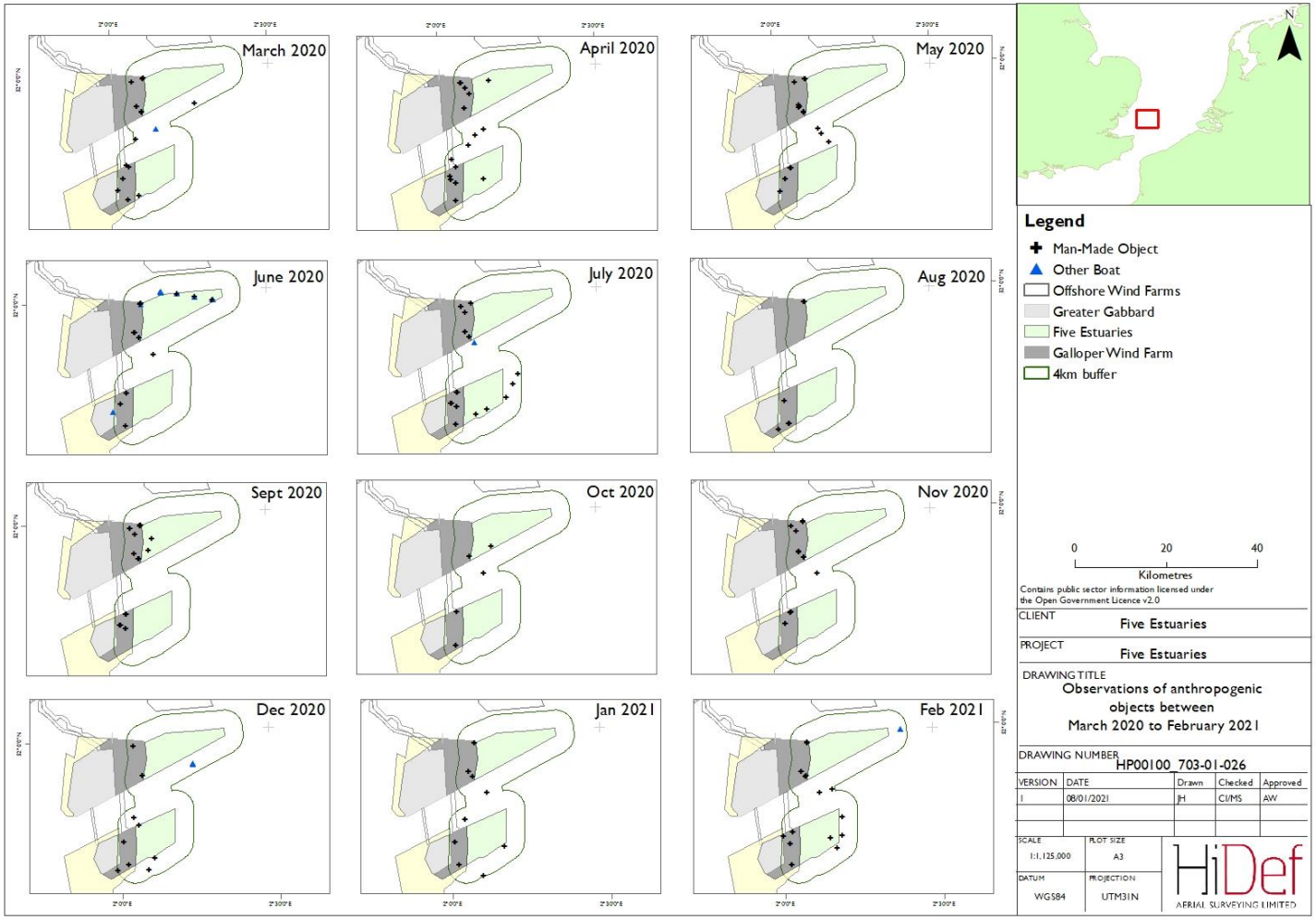


Figure 72 **Detections of vessels and anthropogenic objects between March 2020 and February 2021**



4 Discussion and conclusions

112 Over a two-year period, an area of 606km^2 encompassing the proposed VE wind farm in the North Sea off the east Suffolk coast, was surveyed monthly to characterise fauna use of the area. Generally, low populations of seabirds and marine mammals were observed however, occasional high densities of fulmar, gannet, kittiwake, lesser black-backed gull, great black-backed gull, guillemot, razorbill and harbour porpoise were present. This may be attributed to the proximity of the site to multiple designated protected areas for seabirds and marine mammals.

113 Between March 2019 and February 2021, 24 monthly surveys were successful in characterising bird and mammal species present across the VE survey area, recording a total 8,356 birds of 23 species and 583 marine mammals of two species. Additionally, 768 birds were partially identified to 16 separate species groups and 39 non-avian animals were partially identified to three species groups. The identification rate achieved to species level was 91.23% across the survey programme.

114 For all focal bird species with the exception of great black-backed gulls, more birds were recorded in Year 1 compared to Year 2. This was especially true for guillemots where over three times as many birds were recorded in the first year of data collection.

115 Low numbers of fulmar were recorded intermittently throughout the survey period, with more birds observed in the first year compared to the second. Fulmars are a highly pelagic species, only returning the coast during the breeding season. Declines in observations post-breeding are consistent with data for other areas of south-east England where marked declines in fulmar observations were experienced from mid-September (Cook *et al.,* 2006; Newton *et al.,* 2010).

116 Gannets were present throughout the study, with peak observations occurring in November and August 2019. Flight activity increased during these months, comprising 74% of birds in November 2020. Due to the time of year, this likely relates to movements south from breeding colonies. The combination of flying and sitting birds observed during the study suggests the site is also used for foraging. The relatively high flight height associated with foraging and migration make the species vulnerable to collision with offshore wind farms (Cleasby *et al.,* 2015), especially those located along migration routes, such as those in the southern North Sea (Furness *et al.,* 2018).

117 Kittiwakes were one of the most abundant species recorded throughout the two-year period. Density and abundance estimates varied, peaking in spring 2019, with fewer birds present in both the summer and early winter. Kittiwakes are usually distributed in offshore waters in the winter in the southern North Sea (Bogdanova *et al.,* 2011), supported by the present study. Large influxes in March and April, particularly in 2019, could be due to birds travelling to spring breeding sites.

118 Lesser black-backed gulls were recorded throughout the two-year period, with peak densities occurring in the summer months suggesting a linkage with a breeding colony. The nearest breeding site is the Alde-Ore Estuary SPA to the north-west of the survey site, of which lesser black-back gulls are a qualifying species. The Orford Ness and Havergate Island colonies within the SPA are estimated to hold approximately 2000 breeding pairs of lesser black-backed gulls, and although the overall population has experienced declines over the past few decades, this is still an important breeding area for the species (Davis *et al.,* 2018).

119 Great black-backed gulls were recorded in varying numbers at the VE site, peaking in late autumn and winter in both years. The presence of the species at this time of year suggests movement of wintering birds into the area from colonies further afield following breeding. Coastal North Sea populations of great black-backed gulls are known to fluctuate, with increases observed in recent years (Balmer *et*

al., 2013), although the relatively short timescale of this project makes it difficult to determine if increases in populations are occurring around the VE site.

120 Guillemots were the most abundant species throughout the study, recorded in every survey, apart from June 2019. Peak densities in late winter and early spring suggest the area hosts foraging pre-breeding birds prior to migration north to breeding colonies. Decreases in relative and absolute density during the breeding season, coupled with only one juvenile bird throughout the survey programme, suggests the area is not primarily used for breeding or post-breeding dispersal. Many of these birds will be linked to different North Sea SPA populations, such as the Forth Islands SPA, Farne Islands SPA and the Flamborough and Filey Coast SPA. Displacement by offshore wind farms might occur for this species, with a strong avoidance effect around offshore wind farms displayed by guillemots in some studies of other areas of the North Sea (Furness *et al.,* 2013).

121 The presence of razorbills was generally similar to guillemot, with peak densities in late winter and spring likely relating to birds gathering before moving north in the breeding season. The paucity of summer records suggests birds from UK colonies do not venture to feed in the VE survey area at this time and it is likely survey area is not used post-breeding, as with guillemot, for moulting. Relative and absolute density estimates varied between January and March but were notable enough to suggest that a winter population does exist in the survey area.

122 Red-throated diver were present in the survey area in both years, with over twice as many birds recorded in Year 2. Divers were observed in higher numbers in Year 2 compared to Year 1, with observations occurring in 33% and 58% of surveys in Year 1 and 2 respectively. Peaks in observations occurred in winter months, such as in February 2020 and January 2021, which is to be expected for the species (Webb *et al.,* 2009; Irwin *et al.,* 2018). Proximity of the study site to the Outer Thames Estuary and Greater Wash SPAs may influence the numbers of divers in the area. Low numbers recorded during the study suggest that the area is currently not of high value to the species.

123 Harbour porpoise are the commonest cetacean species in the North Sea (Hammond *et al.,* 2013), and consequently were the most abundant non-avian animal species observed during the two-year study period. High abundances of harbour porpoise may be attributed to its generally high abundance throughout the North Sea however, on a regional scale, densities are likely to be influenced by the proximity of the VE site to the Southern North Sea SAC, of which harbour porpoise is a species of interest. Selection of shallow, continental shelf environments is likely to contribute to the high densities present within the survey area (Waggitt *et al.,* 2020), with high relative and absolute density estimates from late summer (August) through to November, which decreased in the spring.

124 Atlantic grey seals were the only other non-avian animal identified to species level during the two-year study, present in very low numbers. The distance of the VE wind farm from the coast and the sporadic nature of grey seal observations during the study suggests the site is rarely used during foraging.

125 Multiple species recorded within the proposed site boundary, such as guillemots and red-throated divers, have been previously identified as prone to disturbance and displacement from the presence of offshore wind farms. Additionally, other species regularly observed during the two-year period such as gannets, kittiwakes and lesser black-backed gulls are known to fly at potential collision risk height (Johnston *et al.,* 2014).

126 The study provided robust distribution and density data for multiple seabird and marine mammal species in the southern North Sea off the east coast of Suffolk. Regular data collection spanning the two-year period is essential to determine trends in distributions and abundance of marine species

over multiple seasons. Data provided by the two-year study will be imperative to ensure development of the area can proceed with minimal risk to marine populations.

5 References

Balmer, D.E., Gillings, S., Caffrey, B.J., Swann, R.L., Downie, I.S. and Fuller, R.J. 2013. *Bird Atlas 2007-11: the breeding and wintering birds of Britain and Ireland*. Thetford: BTO.

Barlow J, Oliver C.W., Jackson T.D. and Taylor B.L. 1988. Harbour porpoise *Phocoena phocoena*, abundance estimation for California, Oregon and Washington: II. *Fishery Bulletin* 86: 433-444.

Bogdanova, M.I., Daunt, F., Newell, M., Phillips, R.A., Harris, M.P. and Wanless, S. 2011. Seasonal interactions in the black-legged kittiwake, Rissa tridactyla: links between breeding performance and winter distribution. *Proceedings of the Royal Society B: Biological Sciences,* 278, 2412–2418.

Borchers D.L., Buckland S.T. and Zucchini W. 2002. *Estimating Animal Abundance: Closed Populations.* Springer, Berlin.

Buckland, S. T., Anderson, D. R., Burnham, K. P. Laake, J. L. Borchers, D. L. and Thomas, L. 2001. *Introduction to Distance Sampling*. OUP, Oxford.

Cleasby, I.R., Wakefield, E.D., Bearhop, S., Bodey, T.W., Votier, S.C. and Hamer, K.C. 2015. Three-dimensional tracking of a wide-ranging marine predator: flight heights and vulnerability to offshore wind farms. *Journal of applied ecology*, 52(6), 1474-1482.

Cook, A.S.C.P., Thaxter, C., Wright, L.J., Moran, N.J., Burton, N.H.K., Andrews, J., Barker, S. and Cooke, F. 2006. *Analysis of sea-watching data from Holme Bird Observatory, Norfolk*. BTO Research Report 629. British Trust for Ornithology, Norfolk.

Davis, S., Sharps, E., Brown, A., Lock, L., Wilson, L. and Bolton, M. 2018. *Breeding success of sympatric Herring Gulls Larus argentatus and Lesser Black-backed Gulls Larus fuscus breeding at two adjacent colonies with contrasting population trends.* RSPB Research Report 62. RSPB Centre for Conservation Science, Bedfordshire.

Furness, R.W., Hallgrimsson, G.T., Montevecchi, W.A., Fifield, D., Kubetzki, U., Mendel, B. and Garthe, S. 2018. Adult Gannet migrations frequently loop clockwise around Britain and Ireland. *Ringing & Migration*, 33(1), pp.45-53.

Furness, R.W., Wade, H.M. and Masden, E.A. 2013. Assessing vulnerability of marine bird populations to offshore wind farms. *Journal of environmental management*, 119, pp.56-66.

Hammond, P.S., Macleod, K., Berggren, P., Borchers, D.L., Burt, L., Cañadas, A., Desportes, G., Donovan, G.P., Gilles, A., Gillespie, D. and Gordon, J. 2013. Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management. *Biological Conservation*, 164, 107-122.

Johnston, A., Cook, A.S., Wright, L.J., Humphreys, E.M. and Burton, N.H. 2014. Modelling flight heights of marine birds to more accurately assess collision risk with offshore wind turbines. *Journal of Applied Ecology*, 51(1), pp.31-41.

Irwin, C., Scott, M., S., Humphries, G. and Webb, A. 2019. *HiDef report to Natural England - Digital video aerial surveys of red-throated diver in the Outer Thames Estuary Special Protection Area 2018*. Natural England Commissioned Reports, 260.

Newton, I., Ekner, A., Walker, D. and Sparks, T.H. 2010. The migration seasons of birds as recorded at Dungeness Bird Observatory in southeast England. *Ringing & Migration*, 25(2), pp.71-87.

Simonoff J. S. 1996. *Smoothing Methods in Statistics*. Springer, London.Spencer,

Spencer, S.M. 2012. *Diving behaviour and identification of sex of breeding Atlantic puffins (Fratercula arctica), and nest-site characteristics of Alcids on Petit Manan Island, Maine*. MSc Thesis submitted to University of Massachusetts Amherst May 2012.

Teilmann, J., Christiansen, C.T., Kjellerup, S., Dietz, R., and Nachmann, G. 2013. Geographic, seasonal, and diurnal surface behavior of harbor porpoises. *Marine Mammal Science*, 29: 60–76.

Thaxter C.B., Wanless S., Daunt F., Harris M.P., Benvenuti S., Watanuki Y., Grémillet D. and Hamer K.C. 2010. Influence of wing loading on the trade-off between pursuit-diving and flight in common guillemots and razorbills. *The Journal of Experimental Biology,* 213, 1018-1025.

Thaxter, C.B., Ross-Smith, V.H. and Cook, A.S.C.P. 2016. *How high do birds fly? A review of current datasets and an appraisal of current methodologies for collecting flight height data: Literature review*. BTO Research Report No. 666.

Waggitt, J.J., Evans, P.G., Andrade, J., Banks, A.N., Boisseau, O., Bolton, M., Bradbury, G., Brereton, T., Camphuysen, C.J., Durinck, J. and Felce, T. 2020. Distribution maps of cetacean and seabird populations in the North-East Atlantic. *Journal of Applied Ecology*, 57(2), pp.253-269.

Webb, A., Dean, B.J., O'Brien, S.H., Söhle, I., McSorley, C.A., Reid, J.B., Cranswick, P.A., Smith, L.E. and Hall, C. 2009. *The numbers of inshore waterbirds using the Greater Thames during the non-breeding season: an assessment of the area's potential for qualification as a marine SPA*. JNCC Report, 374.

Appendix I: Non-adjusted abundance estimates

127 The density, total estimated population, upper and lower 95% CI, standard deviation and CV for each species and species group have been calculated using strip transect analysis and are presented here for each of the 12 surveys undertaken. A description of the values presented can be found in Table 11.

Table 39 Abundance and density estimates of species groups in the survey area during Survey 1 on 26 March 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	15.55	9424	6818	12268	1409	14.94%
All non-avian animals	0.31	189	93	310	56	29.58%
Species group						
Diver species	0.02	14	0	33	9	65.41%
Fulmar / gull species	0.32	197	121	279	41	20.65%
Gannet species	0.84	507	167	1020	229	45.20%
Grebe species	0.01	7	0	21	7	97.57%
Small gull species	4.20	2546	1886	3340	374	14.67%
Black-backed gull species	0.01	7	0	20	7	93.71%
Large gull species	0.03	20	0	50	14	67.03%
Gull species	0.01	7	0	21	7	99.37%
Large auk	9.42	5711	4126	7502	865	15.14%
Auk species	0.69	418	219	659	114	27.10%
Auk / small gull	0.04	27	7	53	12	42.74%
Seal species	0.03	21	0	41	11	50.24%
Cetacean species	0.27	163	66	284	58	35.21%
Seal / small cetacean species	0.01	7	0	20	7	93.54%

Table 40 Abundance and density estimates of species in the survey area during Survey 1 on 26 March 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Red-throated diver	0.02	14	0	33	9	65.39%
Fulmar	0.29	175	111	253	37	20.77%
Gannet	0.82	498	161	1016	231	46.31%
Kittiwake	4.05	2457	1797	3224	367	14.92%
Black-headed gull	0.06	34	0	82	23	66.67%
Lesser black-backed gull	0.01	7	0	20	7	90.94%
Great black-backed gull	0.03	21	0	51	14	66.44%
Guillemot	6.02	3649	2509	4892	611	16.74%
Razorbill	3.70	2242	1550	3021	381	16.96%
Puffin	0.01	7	0	20	7	92.07%
Grey seal	0.01	7	0	20	7	91.85%
Harbour porpoise	0.26	155	60	279	57	36.59%

Table 41 Abundance and density estimates of species groups in the survey area during Survey 2 on 5 April 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	5.99	3633	2906	4390	378	10.38%
All non-avian animals	0.07	40	7	76	18	44.06%
Species group						
Fulmar / gull species	0.07	40	13	73	16	40.08%
Gannet species	0.29	178	111	254	37	20.51%
Small gull species	1.22	740	487	1016	136	18.29%
Black-backed gull species	0.27	164	25	368	91	55.63%
Large gull species	0.11	67	0	157	41	60.49%
Gull species	0.01	7	0	20	7	94.86%
Tern species	0.01	7	0	20	7	92.34%
Large auk	3.89	2356	1801	2973	302	12.78%
Auk species	0.09	53	13	103	23	42.99%
Auk / small gull	0.03	20	0	52	14	70.81%
Cetacean species	0.06	40	7	77	18	44.85%

Table 42 Abundance and density estimates of species in the survey area during Survey 2 on 5 April 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Fulmar	0.05	33	13	58	12	35.61%
Gannet	0.29	177	112	253	37	20.46%
Kittiwake	1.18	716	466	1002	136	19.00%
Little gull	0.02	13	0	40	13	94.23%
Common gull	0.01	7	0	20	7	94.77%
Lesser black-backed gull	0.32	196	44	417	98	49.88%
Great black-backed gull	0.07	40	0	105	30	73.70%
Sandwich tern	0.01	7	0	20	7	92.46%
Guillemot	3.30	2002	1516	2554	266	13.25%
Razorbill	0.50	304	182	436	66	21.71%
Harbour porpoise	0.06	40	7	77	18	44.14%

Table 43 Abundance and density estimates of species groups in the survey area during Survey 3 on 11 May 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	1.15	696	482	913	111	15.86%
All non-avian animals	0.03	20	0	52	14	68.69%
Species group						
Fulmar / gull species	0.27	167	113	226	29	17.26%
Gannet species	0.03	21	0	40	10	49.91%
Small gull species	0.52	317	161	476	81	25.39%
Large gull species	0.04	27	0	59	15	55.53%
Gull species	0.01	7	0	20	7	101.94%
Arctic / common tern	0.03	20	0	59	19	93.53%
Large auk	0.21	126	59	197	35	27.70%
Auk species	0.01	7	0	20	7	91.23%
Auk / small gull	0.01	7	0	20	7	93.21%
Cetacean species	0.03	21	0	51	14	67.78%

Table 44 Abundance and density estimates of species in the survey area during Survey 3 on 11 May 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Fulmar	0.17	106	58	160	27	24.99%
Gannet	0.03	20	0	40	10	49.70%
Kittiwake	0.57	344	192	509	82	23.82%
Lesser black-backed gull	0.04	27	0	59	15	55.74%
Guillemot	0.12	73	33	117	22	29.51%
Razorbill	0.09	53	13	100	22	40.53%
Harbour porpoise	0.03	20	0	51	14	68.23%

Table 45 Abundance and density estimates of species groups in the survey area during Survey 4 on 6 June 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	4.13	2505	475	6076	1658	66.19%
All non-avian animals	0.14	88	27	155	33	37.12%
Species group						
Fulmar / gull species	0.28	168	39	341	78	46.52%
Gannet species	0.59	356	71	758	187	52.28%
Small gull species	0.41	248	144	404	70	28.15%
Black-backed gull species	1.17	713	41	1916	569	79.87%
Large gull species	1.66	1006	40	2886	880	87.40%
Gull species	0.03	21	0	41	11	50.92%
Cetacean species	0.14	88	27	153	32	36.31%

Table 46 Abundance and density estimates of species in the survey area during Survey 4 on 6 June 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Fulmar	0.19	115	31	213	47	40.77%
Gannet	0.59	358	72	770	189	52.71%
Kittiwake	0.41	249	139	414	73	29.32%
Common gull	0.01	7	0	20	7	91.70%
Lesser black-backed gull	2.64	1601	79	4481	1354	84.56%
Herring gull	0.14	88	0	244	74	84.06%
Great black-backed gull	0.02	14	0	33	9	62.52%
Harbour porpoise	0.15	89	27	154	32	35.49%

Table 47 Abundance and density estimates of species groups in the survey area during Survey 5 on 1 July 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	2.32	1404	287	3452	986	70.20%
All non-avian animals	0.11	68	27	114	23	33.46%
Species group						
Fulmar / gull species	0.09	53	0	148	45	84.19%
Gannet species	0.14	87	38	147	29	32.55%
Small gull species	0.10	61	27	101	20	31.63%
Black-backed gull species	0.01	7	0	21	7	97.65%
Large gull species	1.78	1077	64	3015	922	85.62%
Arctic / common tern	0.01	7	0	20	7	93.16%
Tern species	0.01	7	0	20	7	97.00%
Large auk	0.13	80	20	153	35	42.99%
Cetacean species	0.11	68	27	114	23	33.46%

Table 48 Abundance and density estimates of species in the survey area during Survey 5 on 1 July 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Fulmar	0.08	48	0	133	39	82.30%
Gannet	0.14	88	38	149	30	33.29%
Kittiwake	0.10	61	27	100	19	31.45%
Lesser black-backed gull	1.69	1027	54	2831	872	84.88%
Herring gull	0.13	81	0	215	64	78.36%
Guillemot	0.12	73	13	148	36	48.17%
Razorbill	0.01	7	0	20	7	93.77%
Harbour porpoise	0.11	67	27	115	23	34.19%

Table 49 Abundance and density estimates of species groups in the survey area during Survey 6 on 28 August 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	3.51	2127	1485	2900	360	16.91%
All non-avian animals	0.55	331	194	518	84	25.38%
Species group						
Fulmar / gull species	0.61	372	113	715	158	42.52%
Gannet species	1.11	674	436	925	129	19.07%
Skua species	0.04	28	7	48	11	40.02%
Small gull species	0.16	95	50	148	26	27.15%
Black-backed gull species	0.90	547	158	1034	225	41.14%
Large gull species	0.26	156	34	344	85	54.40%
Gull species	0.14	88	33	154	31	35.04%
Arctic / common tern	0.07	41	0	90	22	54.12%
Tern / small gull species	0.02	14	0	33	9	65.71%
Large auk	0.15	94	26	194	45	47.98%
Auk species	0.02	14	0	34	9	67.16%
Seal species	0.02	14	0	33	9	66.46%
Cetacean species	0.51	308	169	494	85	27.57%
Seal / small cetacean species	0.01	7	0	21	7	98.65%

Table 50 Abundance and density estimates of species in the survey area during Survey 6 on 28 August 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Fulmar	0.44	265	81	484	103	38.89%
Gannet	1.11	670	439	924	126	18.76%
Great skua	0.04	27	7	51	12	41.18%
Kittiwake	0.16	95	39	161	32	32.86%
Lesser black-backed gull	1.03	624	200	1133	246	39.31%
Herring gull	0.07	41	13	74	16	39.18%
Great black-backed gull	0.05	28	0	66	17	60.03%
Guillemot	0.13	80	14	176	44	55.39%
Razorbill	0.02	14	0	41	14	97.06%
Grey seal	0.02	14	0	34	9	66.85%
Harbour porpoise	0.51	312	174	494	85	27.21%

Table 51 Abundance and density estimates of species groups in the survey area during Survey 7 on 10 September 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	2.24	1357	763	2182	375	27.63%
All non-avian animals	0.51	310	232	390	41	13.14%
Species group						
Diver species	0.01	7	0	20	7	94.16%
Fulmar / gull species	0.72	439	131	824	184	41.86%
Gannet species	0.22	135	92	172	21	15.54%
Cormorant species	0.06	40	0	120	38	96.06%
Skua species	0.02	14	0	33	9	61.45%
Skua species excluding great	0.01	7	0	20	7	91.24%
Small gull species	0.39	235	87	430	89	37.84%
Black-backed gull species	0.28	168	47	349	82	48.70%
Large gull species	0.39	237	86	461	101	42.44%
Gull species	0.03	21	0	44	11	51.41%
Arctic / common tern	0.02	14	0	41	13	92.80%
Large auk	0.07	41	7	87	21	51.07%
Auk species	0.01	7	0	20	7	98.03%
Seal species	0.01	7	0	21	7	98.22%
Cetacean species	0.47	284	217	359	37	12.89%

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Seal / small cetacean species	0.03	21	0	53	15	69.53%

Table 52 Abundance and density estimates of species in the survey area during Survey 7 on 10 September 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Red-throated diver	0.01	7	0	21	7	96.18%
Fulmar	0.41	251	58	496	116	45.91%
Gannet	0.22	135	93	173	21	15.26%
Cormorant	0.07	41	0	120	39	95.57%
Arctic skua	0.01	7	0	21	7	94.84%
Great skua	0.02	14	0	33	9	62.97%
Kittiwake	0.36	221	88	389	79	35.42%
Black-headed gull	0.01	7	0	21	7	94.04%
Lesser black-backed gull	0.23	143	58	244	48	33.61%
Great black-backed gull	0.36	216	54	454	108	49.63%
Common tern	0.01	7	0	21	7	93.98%
Guillemot	0.04	27	0	60	15	55.94%
Harbour porpoise	0.48	289	219	363	38	12.85%

Table 53 Abundance and density estimates of species groups in the survey area during Survey 8 on 5 October 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	2.58	1561	1130	1992	223	14.22%
All non-avian animals	0.20	121	60	182	31	25.46%
Species group						
Fulmar / gull species	0.07	41	0	90	24	56.95%
Gannet species	0.52	315	166	491	85	26.88%
Skua species excluding great	0.03	21	0	61	20	96.69%
Small gull species	0.22	131	71	192	31	23.05%
Black-backed gull species	0.12	72	20	132	30	41.29%
Large gull species	0.08	50	0	118	31	61.28%
Gull species	0.02	10	0	30	10	95.44%
Tern species	0.02	11	0	30	10	94.78%
Tern / small gull species	0.03	21	0	49	13	61.74%
Large auk	1.42	860	522	1238	183	21.21%
Auk species	0.05	31	0	78	22	68.85%
Auk / small gull	0.02	11	0	30	10	94.32%
Seal species	0.03	21	0	49	13	60.76%
Cetacean species	0.17	101	50	158	28	27.93%

Table 54 Abundance and density estimates of species in the survey area during Survey 8 on 5 October 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Fulmar	0.03	21	0	50	13	64.39%
Gannet	0.51	309	167	495	85	27.27%
Kittiwake	0.11	70	29	121	25	34.93%
Little gull	0.07	41	0	87	22	52.31%
Black-headed gull	0.03	20	0	49	13	62.69%
Lesser black-backed gull	0.02	11	0	31	10	96.83%
Herring gull	0.02	11	0	31	10	94.17%
Great black-backed gull	0.15	91	30	160	34	36.88%
Sandwich tern	0.02	11	0	31	10	93.58%
Guillemot	0.45	274	152	398	63	22.89%
Razorbill	0.83	502	250	787	141	27.96%
Harbour porpoise	0.17	101	49	159	29	28.38%

Table 55 Abundance and density estimates of species groups in the survey area during Survey 9 on 6 November 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	6.46	3918	3238	4579	347	8.85%
All non-avian animals	1.29	780	518	1042	135	17.31%
Species group						
Fulmar / gull species	0.1	61	10	127	30	49.07%
Gannet species	2.27	1374	1045	1736	178	12.91%
Small gull species	1.03	623	388	899	132	21.16%
Large gull species	0.13	81	10	164	40	49.02%
Gull species	0.05	31	0	75	20	64.98%
Tern / small gull species	0.02	10	0	30	10	95.73%
Large auk	2.68	1624	1229	2073	216	13.28%
Auk species	0.13	81	20	149	33	40.39%
Auk / small gull	0.07	40	0	107	30	74.76%
Seal species	0.02	11	0	30	10	95.24%
Cetacean species	1.27	770	516	1041	135	17.42%

Table 56 Abundance and density estimates of species in the survey area during Survey 9 on 6 November 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Fulmar	0.03	21	0	49	13	63.47%
Gannet	2.26	1370	1041	1741	179	13.06%
Kittiwake	0.96	580	314	945	163	27.99%
Little gull	0.07	41	0	88	22	54.59%
Black-headed gull	0.03	20	0	48	13	61.48%
Lesser black-backed gull	0.05	31	0	77	21	66.57%
Herring gull	0.03	21	0	48	13	60.56%
Great black-backed gull	0.1	61	0	130	33	53.20%
Guillemot	1.8	1091	793	1415	159	14.53%
Razorbill	0.68	414	183	669	124	29.95%
Harbour porpoise	1.27	773	512	1042	137	17.65%

Table 57 Abundance and density estimates of species groups in the survey area during Survey 10 on 23 December 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	6.79	4117	3345	4969	415	10.08%
All non-avian animals	0.19	116	54	186	34	28.72%
Species group						
Diver species	0.01	7	0	21	7	95.66%
Fulmar / gull species	0.01	7	0	21	7	94.53%
Gannet species	0.02	14	0	34	9	65.96%
Small gull species	0.92	561	397	749	91	16.14%
Large gull species	0.11	68	14	127	29	42.34%
Gull species	0.01	7	0	21	7	95.10%
Large auk	5.57	3380	2672	4165	385	11.38%
Auk species	0.04	27	0	60	15	54.53%
Auk / small gull	0.03	21	0	41	11	52.63%
Large auk / diver species	0.01	7	0	20	7	92.78%
Small bird species	0.01	7	0	21	7	98.57%
Seal species	0.06	34	0	77	20	58.35%
Cetacean species	0.13	82	33	141	29	34.98%

Table 58 Abundance and density estimates of species in the survey area during Survey 10 on 23 December 2019

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Red-throated diver	0.01	7	0	21	7	96.64%
Gannet	0.02	14	0	34	9	66.42%
Kittiwake	0.93	562	396	763	95	16.79%
Common gull	0.01	7	0	21	7	94.01%
Lesser black-backed gull	0.04	28	0	59	15	51.91%
Herring gull	0.01	7	0	21	7	91.28%
Great black-backed gull	0.04	27	0	71	20	72.07%
Guillemot	1.87	1136	863	1443	150	13.12%
Razorbill	3.23	1960	1258	2784	390	19.86%
Harbour porpoise	0.13	81	32	140	29	34.83%

Table 59 Abundance and density estimates of species groups in the survey area during Survey 11 on 18 January 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	4.13	2501	1835	3212	351	14.01%
All non-avian animals	0.07	46	0	113	31	67.41%
Species group						
Fulmar / gull species	0.08	46	9	89	20	43.87%
Grebe species	0.02	10	0	28	9	94.78%
Small gull species	0.45	275	81	593	136	49.22%
Black-backed gull species	0.05	28	0	60	15	51.19%
Large gull species	0.05	28	0	61	15	52.38%
Gull species	0.02	10	0	28	9	96.47%
Large auk	3.13	1895	1446	2298	219	11.55%
Auk species	0.21	129	19	286	69	53.72%
Auk / small gull	0.09	55	18	100	22	39.65%
Large auk / diver species	0.05	28	0	60	15	52.77%
Seal species	0.02	10	0	28	9	92.33%
Cetacean species	0.06	38	0	90	24	64.60%

Table 60 Abundance and density estimates of species in the survey area during Survey 11 on 18 January 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Fulmar	0.05	28	0	55	14	50.43%
Great crested grebe	0.02	10	0	28	9	94.71%
Kittiwake	0.44	267	80	566	132	49.53%
Common gull	0.02	10	0	28	9	91.33%
Herring gull	0.03	19	0	46	13	67.45%
Great black-backed gull	0.06	37	9	70	16	41.49%
Guillemot	2.37	1439	1052	1808	194	13.46%
Razorbill	0.74	449	243	680	113	25.01%
Harbour porpoise	0.06	37	0	90	25	67.03%

Table 61 Abundance and density estimates of species groups in the survey area during Survey 12 on 14 February 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	21.03	12746	9175	16282	1823	14.30%
All non-avian animals	0.20	121	51	200	39	31.58%
Species group						
Diver species	0.03	21	7	40	10	47.36%
Fulmar / gull species	0.02	14	0	33	9	65.17%
Gannet species	0.55	334	144	548	104	30.95%
Small gull species	0.97	587	316	963	171	29.05%
Large gull species	0.02	14	0	33	9	66.63%
Gull species	0.06	34	0	73	18	52.48%
Large auk	17.92	10864	7866	13960	1572	14.47%
Auk species	1.03	625	351	930	150	23.98%
Auk / small gull	0.19	114	32	211	47	40.78%
Large auk / diver species	0.33	201	94	315	57	27.94%
Small bird species	0.01	7	0	20	7	93.75%
Seal species	0.02	14	0	33	9	63.79%
Cetacean species	0.17	101	39	176	36	35.31%
Seal / small cetacean species	0.01	7	0	20	7	92.07%

Table 62 Abundance and density estimates of species in the survey area during Survey 12 on 14 February 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Red-throated diver	0.06	34	7	65	15	41.93%
Fulmar	0.01	7	0	25	7	98.35%
Gannet	0.55	335	152	551	103	30.59%
Kittiwake	0.93	564	338	861	136	24.08%
Common gull	0.06	34	0	90	26	75.39%
Lesser black-backed gull	0.01	7	0	20	7	96.34%
Great black-backed gull	0.01	7	0	20	7	94.74%
Guillemot	15.09	9150	6654	11798	1338	14.62%
Razorbill	2.53	1533	959	2228	325	21.15%
Grey seal	0.01	7	0	20	7	93.70%
Harbour porpoise	0.17	102	40	178	36	35.52%

Table 63 Abundance and density estimates of species groups in the survey area during Survey 13 on 11 March 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	3.46	2097	1624	2616	248	11.82%
All non-avian animals	0.38	228	160	299	36	15.74%
Species group						
Diver species	0.01	7	0	21	7	97.65%
Fulmar / gull species	0.03	21	0	46	11	53.17%
Wader species	0.04	27	0	80	26	96.25%
Small gull species	0.41	249	124	379	66	26.26%
Large gull species	0.02	14	0	34	10	67.63%
Gull species	0.01	7	0	21	7	95.96%
Large auk	2.92	1771	1383	2185	204	11.51%
Auk / small gull	0.01	7	0	20	7	90.85%
Seal species	0.01	7	0	20	7	95.88%
Cetacean species	0.37	222	160	287	33	14.67%

Table 64 Abundance and density estimates of species in the survey area during Survey 13 on 11 March 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Red-throated diver	0.01	7	0	21	7	96.94%
Fulmar	0.02	14	0	33	9	67.76%
Golden plover	0.04	27	0	81	26	98.24%
Kittiwake	0.38	229	122	345	57	24.83%
Common gull	0.05	34	0	81	21	61.87%
Lesser black-backed gull	0.01	7	0	21	7	96.76%
Great black-backed gull	0.01	7	0	21	7	100.12%
Guillemot	1.39	846	600	1107	130	15.26%
Razorbill	1.31	797	562	1049	126	15.80%
Harbour porpoise	0.36	216	148	285	36	16.30%

Table 65 Abundance and density estimates of species groups in the survey area during Survey 14 on 09 April 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	2.21	1340	857	1914	274	20.41%
All non-avian animals	0.3	182	96	284	49	26.83%
Species group						
Diver species	0.02	14	0	33	9	63.30%
Gannet species	0.02	14	0	33	9	62.57%
Skua species	0.01	7	0	20	7	90.28%
Small gull species	0.39	236	138	338	52	21.85%
Large gull species	0.17	102	14	228	58	56.48%
Gull species	0.01	7	0	21	7	97.79%
Arctic / common tern	0.01	7	0	20	7	90.96%
Tern species	0.01	7	0	21	7	96.94%
Large auk	1.51	913	496	1420	236	25.81%
Auk / small gull	0.07	41	0	94	25	59.71%
Seal species	0.02	14	0	33	9	65.89%
Cetacean species	0.28	168	84	267	48	28.25%

Table 66 Abundance and density estimates of species in the survey area during Survey 14 on 09 April 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Red-throated diver	0.02	14	0	33	9	63.88%
Gannet	0.02	14	0	33	9	63.10%
Great skua	0.01	7	0	20	7	90.23%
Kittiwake	0.11	68	33	107	20	28.15%
Little gull	0.01	7	0	21	7	94.66%
Common gull	0.18	108	52	175	33	29.88%
Lesser black-backed gull	0.14	88	13	207	55	62.59%
Herring gull	0.02	14	0	41	14	99.52%
Guillemot	1.31	795	414	1254	214	26.86%
Razorbill	0.18	108	39	202	43	39.30%
Grey seal	0.01	7	0	20	7	94.58%
Harbour porpoise	0.28	169	85	269	48	28.35%

Table 67 Abundance and density estimates of species groups in the survey area during Survey 15 on 03 May 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	1.4	852	626	1099	121	14.21%
All non-avian animals	1.11	675	403	998	156	23%
Species group						
Diver species	0.02	14	0	41	13	91.95%
Fulmar / gull species	0.1	63	14	122	28	44.12%
Gannet species	0.01	8	0	21	7	91.52%
Small gull species	0.3	180	110	251	36	19.71%
Black-backed gull species	0.02	15	0	34	10	67.04%
Large gull species	0.07	42	14	75	16	38.75%
Gull species	0.01	7	0	21	7	96.77%
Arctic / common tern	0.01	7	0	21	7	95.19%
Large auk	0.81	489	324	661	87	17.68%
Auk species	0.05	28	7	53	12	40.85%
Auk / small gull	0.01	7	0	21	7	91.02%
Seal species	0.01	8	0	21	7	99.29%
Cetacean species	1.08	657	383	987	155	23.59%
Seal / small cetacean species	0.02	14	0	34	9	62.05%

Table 68 Abundance and density estimates of species in the survey area during Survey 15 on 03 May 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Red-throated diver	0.02	14	0	42	13	91.74%
Fulmar	0.1	63	14	122	27	42.99%
Gannet	0.01	7	0	21	7	92.63%
Kittiwake	0.3	180	114	251	36	19.74%
Lesser black-backed gull	0.08	49	14	87	19	38.14%
Herring gull	0.01	7	0	21	7	99.05%
Common tern	0.01	7	0	21	7	95.53%
Guillemot	0.66	401	251	557	79	19.52%
Razorbill	0.09	55	0	117	29	52.76%
Harbour porpoise	1.08	654	375	981	154	23.43%

Table 69 Abundance and density estimates of species groups in the survey area during Survey 16 on 20 June 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	2.25	1364	588	2684	625	45.81%
All non-avian animals	0.21	128	77	186	29	22.17%
Species group						
Fulmar / gull species	0.03	21	0	41	11	50.43%
Gannet species	0.04	27	7	57	14	50.50%
Small gull species	0.16	94	38	162	33	34.45%
Black-backed gull species	0.18	108	53	171	31	28.27%
Large gull species	1.47	889	229	2068	565	63.48%
Gull species	0.11	67	14	152	39	56.76%
Arctic / common tern	0.06	40	0	120	38	96.31%
Large auk	0.19	116	39	245	55	46.98%
Passerine species	0.01	7	0	20	7	93.64%
Seal species	0.02	14	0	33	10	67.58%
Cetacean species	0.19	115	67	166	26	22.07%

Table 70 Abundance and density estimates of species in the survey area during Survey 16 on 20 June 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Fulmar	0.03	21	0	41	11	51.24%
Gannet	0.04	27	7	54	14	49.19%
Kittiwake	0.17	102	40	170	34	32.86%
Lesser black-backed gull	1.73	1047	313	2325	611	58.31%
Herring gull	0.01	7	0	20	7	93.65%
Common tern	0.02	14	0	41	13	93.54%
Guillemot	0.08	47	19	80	17	34.30%
Feral pigeon	0.01	7	0	20	7	90.70%
Harbour porpoise	0.19	115	67	166	26	22.13%

Table 71 Abundance and density estimates of species groups in the survey area during Survey 17 on 21 July 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	1.17	708	518	916	104	14.59%
All non-avian animals	0.3	182	115	251	35	19.29%
Species group						
Fulmar / gull species	0.18	108	34	208	47	42.77%
Gannet species	0.1	61	20	118	27	44%
Small gull species	0.51	309	183	454	69	22.33%
Black-backed gull species	0.01	7	0	21	7	99.19%
Large gull species	0.22	136	72	206	35	25.35%
Gull species	0.04	27	0	60	16	56.11%
Arctic / common tern	0.01	7	0	20	7	92.11%
Large auk	0.08	48	20	79	16	32.10%
Auk / small gull	0.01	7	0	21	7	98%
Seal species	0.01	7	0	20	7	90.25%
Cetacean species	0.28	168	107	236	33	19.63%
Seal / small cetacean species	0.01	7	0	20	7	92.40%

Table 72 Abundance and density estimates of species in the survey area during Survey 17 on 21 July 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Fulmar	0.16	96	27	188	42	44.09%
Gannet	0.1	61	20	119	27	43.62%
Kittiwake	0.29	176	100	261	42	23.46%
Black-headed gull	0.22	137	27	289	69	50.22%
Lesser black-backed gull	0.2	121	60	188	33	27.13%
Herring gull	0.04	27	7	53	12	44.45%
Common tern	0.01	7	0	21	7	92.35%
Guillemot	0.09	54	26	86	16	28.26%
Harbour porpoise	0.29	176	114	241	34	18.85%

Table 73 Abundance and density estimates of species groups in the survey area during Survey 18 on 05 August 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	0.54	329	214	464	65	19.74%
All non-avian animals	0.07	41	7	79	19	45.22%
Species group						
Fulmar / gull species	0.07	41	7	89	22	52.96%
Gannet species	0.07	41	7	82	20	47.23%
Small gull species	0.34	209	125	308	48	22.76%
Black-backed gull species	0.01	7	0	21	7	94.10%
Large gull species	0.03	21	0	45	11	51.66%
Large auk	0.02	14	0	34	9	65.38%
Seal species	0.02	14	0	33	9	62.71%
Cetacean species	0.04	27	0	60	15	55.44%

Table 74 Abundance and density estimates of species in the survey area during Survey 18 on 05 August 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Fulmar	0.04	27	0	75	21	75.60%
Gannet	0.07	41	7	82	20	47.22%
Kittiwake	0.34	209	121	309	49	23.06%
Lesser black-backed gull	0.04	27	7	53	12	43.20%
Herring gull	0.01	7	0	21	7	95.78%
Guillemot	0.01	7	0	21	7	95.81%
Razorbill	0.01	7	0	20	7	95.76%
Grey seal	0.01	7	0	21	7	92.94%
Harbour porpoise	0.04	27	0	60	16	56.16%

Table 75 Abundance and density estimates of species groups in the survey area during Survey 19 on 02 September 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	2.11	1282	906	1717	213	16.55%
All non-avian animals	0.38	228	139	323	47	20.58%
Species group						
Duck species	0.09	54	0	161	52	96%
Fulmar / gull species	0.25	155	14	359	94	60.54%
Gannet species	0.44	269	150	410	68	24.99%
Skua species	0.01	7	0	21	7	99.93%
Small gull species	0.1	61	26	104	21	33.67%
Black-backed gull species	0.06	34	13	60	13	38.20%
Large gull species	0.44	270	65	572	138	51.06%
Gull species	0.06	34	0	78	20	58.65%
Tern species	0.04	27	0	67	18	67.26%
Large auk	0.56	341	196	485	74	21.59%
Auk species	0.04	27	0	66	18	64.99%
Auk / small gull	0.01	7	0	20	7	95.06%
Seal species	0.01	7	0	21	7	98.99%
Cetacean species	0.35	214	127	310	47	21.77%
Seal / small cetacean species	0.01	7	0	21	7	93.84%

Table 76 Abundance and density estimates of species in the survey area during Survey 19 on 02 September 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Wigeon	0.09	53	0	160	51	95.68%
Fulmar	0.04	28	0	61	16	56.39%
Gannet	0.44	270	146	412	68	25.18%
Great skua	0.01	7	0	21	7	99.61%
Kittiwake	0.09	54	20	93	19	34.62%
Common gull	0.01	7	0	20	7	93.07%
Lesser black-backed gull	0.56	340	78	672	154	45.25%
Herring gull	0.07	41	7	87	22	53.12%
Great black-backed gull	0.05	34	0	77	20	58.29%
Common tern	0.04	27	0	67	19	67.05%
Guillemot	0.54	329	185	481	77	23.33%
Harbour porpoise	0.36	216	127	307	47	21.46%

Table 77 Abundance and density estimates of species groups in the survey area during Survey 20 on 09 October 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	2.67	1617	763	2831	550	34.02%
All non-avian animals	0.2	123	50	206	40	32.60%
Species group						
Diver species	0.02	11	0	30	10	91.67%
Gannet species	0.43	263	149	404	66	24.87%
Small gull species	0.27	163	60	297	62	37.79%
Black-backed gull species	0.03	21	0	60	19	91.73%
Large gull species	0.18	111	19	244	62	55.21%
Large auk	0.9	547	298	842	139	25.39%
Auk / shearwater species	0.05	31	0	90	29	92.58%
Passerine species	0.82	496	0	1443	464	93.45%
Cetacean species	0.2	121	50	202	40	32.29%

Table 78 Abundance and density estimates of species in the survey area during Survey 20 on 09 October 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Red-throated diver	0.02	11	0	30	10	92.47%
Gannet	0.43	263	147	404	66	25.08%
Kittiwake	0.23	141	39	280	64	44.96%
Black-headed gull	0.02	11	0	31	10	92.23%
Lesser black-backed gull	0.03	21	0	50	14	64.53%
Herring gull	0.02	11	0	31	11	100.46%
Great black-backed gull	0.15	92	0	254	77	83.49%
Guillemot	0.28	173	39	349	83	47.92%
Razorbill	0.66	403	162	692	137	33.98%
Chaffinch	0.81	494	0	1444	470	95.09%
Harbour porpoise	0.2	122	50	204	40	32.66%

Table 79 Abundance and density estimates of species groups in the survey area during Survey 21 on 05 November 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	2.86	1736	1417	2066	167	9.62%
All non-avian animals	0.48	293	187	398	54	18.43%
Species group						
Fulmar / gull species	0.02	11	0	31	11	100.65%
Gannet species	1.01	613	347	912	144	23.47%
Small gull species	0.42	253	150	358	53	20.87%
Black-backed gull species	0.02	11	0	31	10	94.98%
Large gull species	0.07	41	10	87	21	51.03%
Large auk	1.09	659	415	956	138	20.88%
Auk species	0.22	131	50	226	46	34.37%
Auk / small gull	0.03	21	0	50	14	65.02%
Seal species	0.02	11	0	30	10	93.38%
Cetacean species	0.47	283	181	380	52	18.08%

Table 80 Abundance and density estimates of species in the survey area during Survey 21 on 05 November 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Fulmar	0.02	10	0	31	10	98.38%
Gannet	1.01	614	351	907	146	23.64%
Kittiwake	0.4	243	147	351	53	21.52%
Lesser black-backed gull	0.05	31	0	61	16	50.10%
Herring gull	0.02	10	0	30	10	92.08%
Great black-backed gull	0.02	11	0	30	10	91.39%
Guillemot	0.33	202	139	268	34	16.50%
Razorbill	0.66	403	180	680	130	32.06%
Harbour porpoise	0.46	282	180	379	51	18.08%

Table 81 Abundance and density estimates of species groups in the survey area during Survey 22 on 15 December 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	6.29	3810	2715	4959	571	14.96%
All non-avian animals	0.13	82	20	159	36	44.01%
Species group						
Small gull species	0.48	290	215	364	39	13.18%
Black-backed gull species	0.04	27	0	66	18	63.69%
Large gull species	0.66	402	96	792	180	44.80%
Large auk	4.65	2820	2006	3676	427	15.12%
Auk species	0.21	128	51	233	48	37.44%
Auk / small gull	0.07	41	13	72	16	37.25%
Large auk / diver species	0.01	7	0	20	7	91.31%
Diver species	0.04	27	0	59	15	54.88%
Fulmar / gull species	0.01	7	0	25	7	100.75%
Gannet species	0.11	68	13	137	32	47.20%
Seal species	0.02	14	0	33	9	63.12%
Cetacean species	0.11	67	7	147	36	54.09%

Table 82 Abundance and density estimates of species in the survey area during Survey 22 on 15 December 2020

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Kittiwake	0.49	296	217	372	40	13.22%
Common gull	0.01	7	0	21	7	95.29%
Great black-backed gull	0.52	317	70	669	162	50.96%
Herring gull	0.11	67	7	144	37	54.78%
Lesser black-backed gull	0.06	34	7	63	15	42.62%
Guillemot	2	1210	918	1524	157	12.90%
Razorbill	1.75	1059	672	1464	203	19.14%
Red-throated diver	0.03	20	0	52	14	67.72%
Gannet	0.11	68	14	135	32	46.55%
Grey Seal	0.01	7	0	21	7	95.34%
Harbour porpoise	0.11	69	7	145	36	52.19%

Table 83 Abundance and density estimates of species groups in the survey area during Survey 23 on 22 January 2021

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	3.68	2233	1733	2724	256	11.46%
All non-avian animals	0.28	173	40	369	88	51%
Species group						
Small gull species	0.68	414	236	629	100	24.12%
Large gull species	0.28	171	40	363	85	49.61%
Gull species	0.02	10	0	30	10	92.32%
Large auk	2.3	1396	1083	1701	155	11.10%
Auk species	0.1	62	0	158	42	67.65%
Auk / small gull	0.13	82	29	151	33	39.42%
Large auk / diver species	0.07	41	10	80	19	45.69%
Diver species	0.07	41	10	77	17	41.68%
Gannet species	0.03	21	0	49	13	61.96%
Seal species	0.02	11	0	31	10	95.60%
Cetacean species	0.27	162	40	341	78	48.27%

Table 84 Abundance and density estimates of species in the survey area during Survey 23 on 22 January 2021

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Kittiwake	0.67	404	227	618	100	24.75%
Little gull	0.02	10	0	30	10	93.84%
Great black-backed gull	0.18	111	10	280	77	69.84%
Herring gull	0.02	11	0	30	10	92.06%
Lesser black-backed gull	0.08	51	20	88	19	35.70%
Guillemot	1.5	908	669	1164	126	13.77%
Razorbill	0.64	385	238	540	78	20.06%
Red-throated diver	0.08	51	20	90	20	37.94%
Gannet	0.03	21	0	49	13	63.97%
Harbour porpoise	0.27	162	40	340	78	47.98%

Table 85 Abundance and density estimates of species groups in the survey area during Survey 24 on 13 February 2021

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Broad category						
All birds	3.49	2117	1571	2815	327	15.42%
All non-avian animals	0.24	148	66	245	47	31.57%
Species group						
Diver species	0.02	14	0	33	9	65.52%
Fulmar / gull species	0.04	27	0	65	17	63.08%
Gannet species	0.09	55	7	117	29	52.01%
Small gull species	0.33	202	142	266	32	15.49%
Black-backed gull species	0.01	7	0	21	7	96.96%
Large gull species	0.07	40	7	81	20	47.94%
Gull species	0.01	7	0	20	7	93.80%
Large auk	2.83	1716	1213	2352	295	17.16%
Auk species	0.02	14	0	41	14	97.74%
Auk / small gull	0.02	14	0	50	14	97.80%
Large auk / diver species	0.03	21	0	52	14	68.89%
Seal species	0.05	34	7	67	16	47.20%
Cetacean species	0.18	109	38	191	40	36.91%
Seal / small cetacean species	0.01	7	0	21	7	97%

Table 86 Abundance and density estimates of species in the survey area during Survey 24 on 13 February 2021

Category	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Standard deviation of population estimate (number)	CV (%)
Species						
Red-throated diver	0.04	27	0	59	15	54.48%
Fulmar	0.01	7	0	20	7	91.62%
Gannet	0.09	55	7	115	28	50.98%
Kittiwake	0.29	175	121	236	30	17%
Little gull	0.01	7	0	20	7	95.72%
Common gull	0.03	21	0	41	11	50.88%
Lesser black-backed gull	0.03	21	0	45	11	54.01%
Herring gull	0.01	7	0	20	7	91.78%
Great black-backed gull	0.03	21	0	44	11	50.32%
Guillemot	1.34	810	519	1171	172	21.14%
Razorbill	0.9	545	357	759	103	18.88%
Grey seal	0.01	7	0	20	7	96.75%
Harbour porpoise	0.18	108	39	192	41	37.25%

Appendix II: Adjusted abundance estimates

128 Relative density and abundance estimates for three diving bird species (guillemot, razorbill and puffin) and one marine mammal species (harbour porpoise) were adjusted to account for the number of animals diving at the time of survey (availability bias) as outlined in section 2.6.3. The adjusted or 'absolute' density and population estimates and upper and lower 95% CIs for the four species are presented here for each of the 24 surveys undertaken, alongside the unadjusted 'relative' estimates.

Table 87 **Adjusted density and population estimates for guillemot in the VE survey area between March 2019 and February 2021, taking into account the number of birds that are estimated as being unavailable for detection**

Guillemot	Non-adjusted (relative) abundance estimates				Adjusted (absolute) abundance estimates			
	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)
26 March 2019	6.02	3649	2509	4892	7.46	4516	3119	6109
5 April 2019	3.30	2002	1516	2554	4.09	2481	1877	3183
11 May 2019	0.12	73	33	117	0.15	92	41	145
6 June 2019	0.00	0	0	0	0.00	0	0	0
1 July 2019	0.12	73	13	148	0.15	90	16	182
28 August 2019	0.13	80	14	176	0.16	100	17	225
10 September 2019	0.04	27	0	60	0.05	33	0	74
5 October 2019	0.45	274	152	398	0.56	335	178	491
6 November 2019	1.80	1091	793	1415	2.22	1346	983	1756
23 December 2019	1.87	1136	863	1443	2.31	1396	1051	1781
18 January 2020	2.37	1439	1052	1808	2.89	1753	1243	2341
14 February 2020	15.09	9150	6654	11798	18.61	11283	8066	14637
11 March 2020	1.39	846	600	1107	1.72	1047	734	1364
09 April 2020	1.31	795	414	1254	1.61	980	489	1586
03 May 2020	0.66	401	251	557	0.82	497	307	691
20 June 2020	0.08	47	19	80	0.10	59	25	100

Guillemot	Non-adjusted (relative) abundance estimates				Adjusted (absolute) abundance estimates			
	Density estimate (n/km^2)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Density estimate (n/km^2)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)
21 July 2020	0.09	54	26	86	0.11	65	16	125
05 August 2020	0.01	7	0	21	0.01	9	0	26
02 September 2020	0.54	329	185	481	0.67	407	226	596
09 October 2020	0.28	173	39	349	0.33	204	10	461
05 November 2020	0.33	202	139	268	0.41	250	171	333
15 December 2020	2.00	1210	918	1524	2.46	1493	1092	1938
22 January 2021	1.50	908	669	1164	1.82	1103	797	1445
13 February 2021	1.34	810	519	1171	1.62	987	584	1480

Table 88 Adjusted density and population estimates for razorbill in the VE survey area between March 2019 and February 2021, taking into account the number of birds that are estimated as being unavailable for detection

Razorbill	Non-adjusted (relative) abundance estimates				Adjusted (absolute) abundance estimates			
	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)
26 March 2019	0.22	150	39	331	0.25	175	23	415
5 April 2019	0.45	311	182	453	0.49	341	132	589
11 May 2019	0.93	637	313	1025	1.05	724	282	1304
6 June 2019	0.12	80	0	240	0.14	94	0	282
1 July 2019	0.21	142	0	415	0.37	261	0	779
28 August 2019	9.82	6730	4763	8928	11.55	7919	5618	10444
10 September 2019	12.79	8766	6152	11839	14.93	10237	7024	14056
5 October 2019	2.12	1454	1068	1884	2.48	1698	1207	2215
6 November 2019	0.68	414	183	669	0.8	485	224	780
23 December 2019	2.68	1838	326	3782	3.16	2166	365	4474
18 January 2020	0.74	449	243	680	0.85	512	238	894
14 February 2020	0.76	518	100	1109	0.89	606	94	1338
11 March 2020	1.31	797	562	1049	1.55	943	666	1246
09 April 2020	0.18	108	39	202	0.20	124	32	249
03 May 2020	0.09	55	0	117	0.11	66	0	141
20 June 2020	0	0	0	0	0	0	0	0

Razorbill	Non-adjusted (relative) abundance estimates				Adjusted (absolute) abundance estimates			
	Density estimate (n/km^2)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Density estimate (n/km^2)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)
21 July 2020	0	0	0	0	0	0	0	0
05 August 2020	0.01	7	0	20	0.01	8	0	25
02 September 2020	0	0	0	0	0	0	0	0
09 October 2020	0.66	403	162	692	0.73	442	98	945
05 November 2020	0.66	403	180	680	0.77	473	207	805
15 December 2020	1.75	1059	672	1464	2.03	1233	780	1701
22 January 2021	0.64	385	238	540	0.72	437	185	725
13 February 2021	0.90	545	357	759	1.04	629	385	922

Table 89 Adjusted density and population estimates for puffin in the VE survey area between March 2019 and February 2021, taking into account the number of birds that are estimated as being unavailable for detection

Puffin	Non-adjusted (relative) abundance estimates				Adjusted (absolute) abundance estimates			
	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Density estimate (n/km²)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)
26 March 2019	0.01	7	0	20	0.01	8	0	23
5 April 2019	0.00	0	0	0	0.00	0	0	0
11 May 2019	0.00	0	0	0	0.00	0	0	0
6 June 2019	0.00	0	0	0	0.00	0	0	0
1 July 2019	0.00	0	0	0	0.00	0	0	0
28 August 2019	0.00	0	0	0	0.00	0	0	0
10 September 2019	0.00	0	0	0	0.00	0	0	0
5 October 2019	0.00	0	0	0	0.00	0	0	0
6 November 2019	0.00	0	0	0	0.00	0	0	0
23 December 2019	0.00	0	0	0	0.00	0	0	0
18 January 2020	0.00	0	0	0	0.00	0	0	0
14 February 2020	0.00	0	0	0	0.00	0	0	0
11 March 2020	0.00	0	0	0	0.00	0	0	0
09 April 2020	0.00	0	0	0	0.00	0	0	0
03 May 2020	0.00	0	0	0	0.00	0	0	0
20 June 2020	0.00	0	0	0	0.00	0	0	0

Puffin	Non-adjusted (relative) abundance estimates				Adjusted (absolute) abundance estimates			
	Density estimate (n/km^2)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Density estimate (n/km^2)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)
21 July 2020	0.00	0	0	0	0.00	0	0	0
05 August 2020	0.00	0	0	0	0.00	0	0	0
02 September 2020	0.00	0	0	0	0.00	0	0	0
09 October 2020	0.00	0	0	0	0.00	0	0	0
05 November 2020	0.00	0	0	0	0.00	0	0	0
15 December 2020	0.00	0	0	0	0.00	0	0	0
22 January 2021	0.00	0	0	0	0.00	0	0	0
13 February 2021	0.00	0	0	0	0.00	0	0	0

Table 90 Adjusted density and population estimates for harbour porpoise in the VE survey area between March 2019 and February 2021, taking into account the number of animals that are estimated as being unavailable for detection

Harbour porpoise	Non-adjusted (relative) abundance estimates				Adjusted (absolute) abundance estimates			
	Density estimate (n/km^2)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Density estimate (n/km^2)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)
26 March 2019	0.26	155	60	279	1.52	905	350	1629
5 April 2019	0.06	40	7	77	0.29	196	34	378
11 May 2019	0.03	20	0	51	0.17	113	0	287
6 June 2019	0.15	89	27	154	0.92	545	165	942
1 July 2019	0.11	67	27	115	0.71	431	174	739
28 August 2019	0.51	312	174	494	3.05	1866	1041	2955
10 September 2019	0.48	289	219	363	3.62	2181	1653	2740
5 October 2019	0.17	101	49	159	1.30	775	376	1220
6 November 2019	1.27	773	512	1042	8.48	5160	3418	6955
23 December 2019	0.13	81	32	140	0.96	599	236	1034
18 January 2020	0.06	37	0	90	0.33	205	0	498
14 February 2020	0.17	102	40	178	1.35	812	319	1418
11 March 2020	0.36	216	148	285	1.80	1078	739	1422
09 April 2020	0.28	169	85	269	1.17	709	357	1128
03 May 2020	1.08	654	375	981	5.20	3148	1805	4722
20 June 2020	0.19	115	67	166	0.99	602	351	868

Harbour porpoise	Non-adjusted (relative) abundance estimates				Adjusted (absolute) abundance estimates			
	Density estimate (n/km^2)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)	Density estimate (n/km^2)	Population estimate (number)	Lower 95% confidence limit of population (number)	Upper 95% confidence limit of population (number)
21 July 2020	0.29	176	114	241	1.59	967	627	1325
05 August 2020	0.04	27	0	60	0.20	138	0	307
02 September 2020	0.36	216	127	307	2.32	1394	819	1981
09 October 2020	0.20	122	50	204	1.31	801	328	1339
05 November 2020	0.46	282	180	379	3.07	1882	1201	2530
15 December 2020	0.11	69	7	145	0.69	436	44	916
22 January 2021	0.27	162	40	340	1.49	896	221	1880
13 February 2021	0.18	108	39	192	1.23	735	266	1307

FIVE ESTUARIES
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